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ASSESSMENT OF WATER QUALITY IN THE ESCWA REGION

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ABBREVIATIONS

bcm	billion cubic metres
BOD	Biochemical oxygen demand: The amount of oxygen required to stabilize the organic matter in water by bacterial action under definite conditions of time and temperature (5 days at 20° Celsius, unless otherwise specified.
^{14}C	Carbon fourteen (isotope)
$CaCO_3$	Calcium carbonate
CO_2	Carbon dioxide
COD	Chemical oxygen demand
DO	Dissolved oxygen
ESCWA	Economic and Social Commission for Western Asia
FAO	Food and Agriculture Organization of the United Nations
GAP	Great Anatolian Project
gpd	gallons per day
he	hectares
km	kilometre
lpcd	litres per capita per day
m^3	cubic metre
m^3/s	cubic metres per second
mcm	million cubic metres
mcm/d	million cubic metres per day
mcm/yr	million cubic metres per year
mgd	million gallons per day
mg/l	milligrams per liter
mm	millimetre
NGO	Non-governmental organization

ppm	parts per million, in this report it is considered to be equivalent to milligrams per liter (mg/1).
RI	Rapid Infiltration
SANAX	Strong Acid/Sodium Ion Exchange
Sp. Gr.	Specific gravity
SR	Slow Rate
SS	Suspended Solids
TDS	Total Dissolved Solids
TSE	Treated Sewage Effluent
TSS	Total Suspended Solids
UN/ACC	UN Administrative Committee for Coordination
UNCED	United Nations Conference on Environment and Development (Rio de Janeiro, Brazil, 1992). Also known as the Earth Summit.
UNDDSMS	United Nations Department of Development Support and Management Services
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization

INTRODUCTION

A. BACKGROUND

In the last two decades, environmental changes have been noticed in scale and number. Water-related problems in the ESCWA region have been met mainly by an impact-thinking approach. Research on water quality and its impact on environment has largely been problem-driven and effect-oriented. The water resources researchers have been pushed by reality rather than pulled by the desire to understand the overall water system so as to solve problems stemming from past misuse, which is now threatening the sustainability of water resources. At present, several problems are affecting the same hydrologic process in the different aspects of the water system in the ESCWA region: rapid population growth is forcing intensification of Governments' use of land and water; delayed responses to water quality deterioration and pollutants already discharged into bodies of water or soil; ongoing release of exhaust into the atmosphere, resulting in acid rivers, ongoing dumping of wastewater to the bodies of water, either surface or groundwater.

The current objective of planning and managing water resources is to have sufficient water in time and place, and of a proper quality to serve human requirements. In concept, there should be no differentiation between management of water quality and water quantity in achieving this objective. In practice, however, integrated management of water quality and quantity has only been partially accomplished and has become a major concern confronting water resources managers and Governments. Recent institutional and legislative changes in the ESCWA region have addressed such concerns by establishing a coordinating mechanism between water quality and water resources planning activities.

A common feature of the ESCWA region is scarcity of freshwater resources in terms of per capita of water availability. Of the 13 ESCWA members, eight have no permanent water courses and rely primarily on groundwater, the major part of which is non-renewable. The other five are endowed with perennial rivers and renewable groundwater resources, but the major rivers are shared with other riparian States. The extreme condition are recurring drought. Groundwater in large basins and surface water storage behind large dams are important for maintaining water surplus and mitigating the effects of drought in agricultural areas.

The Gulf subregion has limited surface water resources in ephemeral wadi-systems located mainly in the high lands bordering the Red Sea and the Gulf of Oman. Groundwater is of paramount importance for all Gulf States because of its wide areal distribution and the large reserves which occur in extensive shared aquifer systems. The main problem, however, is that fresh or good quality water is found mainly in the western part of the Arabian Peninsula. The regional flow is eastwards towards the Gulf, where discharge areas, mainly sabkhas, occur. The water reaching the coast becomes brackish or saline where large urban centres have developed and expanded. For this reason, desalination, and to some extent reuse of waste effluent, are being considered main components in the water strategies of the Arab Gulf States.

In addition, increasing water resource development for the purpose of meeting excessive water demand and consequently the targets of economic development are placing immense pressure on available groundwater resources, for example, in Jordan and the Syrian Arab Republic. The result is the depletion of an appreciable part of the reserve. The continuous decline of water levels is causing degradation of groundwater quality and sea-water intrusion in coastal areas. Besides scarcity and limited water resources, contamination from domestic and industrial effluents has increased in small and medium-sized rivers (such as the Barada, Orontes and Zarka), and water from these rivers has become inadequate for different uses. Large rivers in their lower courses, have been contaminated by brackish and saline drainage water. Phreatic aquifers adjacent to urban areas have been polluted to various degrees (for example, the Damascus Plain aquifer and the Nile Delta aquifer). Accordingly, the qualitative and quantitative effects of excessive water resource development and use are expected to become critical issues as excessive development endangers the resource base and limits the level of economic development, unless concerted efforts are exerted at the national and regional levels.

The preparatory committees for United Nations conferences have stressed the need for setting an essential strategy in addressing current water-related problems by considering the integrated water resource management approach. However, it is worth mentioning that in its conventional meaning, integrated water management involves integration of all water uses and all water-dependent sectors. As land use is water-dependent as well as water-impacting, water management will have to be integrated with land use. The land/water integration should include environmental protection of both uplands and downlands so that the fertile lowlands are protected from degradation under silt flows and floods emerging from water-driven degradation of the slopes in the upland basin. The natural unit for such integration is the watershed.

Assessment of water quality includes monitoring of water quality to define the current condition of the water so as to provide the basis for detecting trends and obtaining the information needed to establish water quality standards. Closely related to water quality monitoring are two other activities: water quality survey and surveillance. Consequently, there are many operations involved in the process of assessing water quality. These operations include: objectives (hydrological factors, water use, economic development policies); preliminary surveys (short- or long-term); monitoring design (selection of types of pollutants, station location); field monitoring operations; hydrological monitoring; laboratory activities; data quality control; data storage and reporting; data interpretation; and water management.

From the above, and in the light of the available information on water quality monitoring in the region, it could safely be said that there is a direct need for the design and implementation of a water quality assessment programme in which the water quality monitoring operations are clearly defined. The type of water source to be studied, be it rivers, lakes and reservoirs or groundwater, has great bearing on the selection of survey and monitoring options as well as the eventual use intended.

B. Justification

It is generally agreed that water is one of the world's most precious resources, and it must be managed—effectively and efficiently—around the world, particularly in the ESCWA region, which is characterized by its situation in arid and semi-arid zones and of scarce water resources. Needs, policies and practices vary from one country to another, but an adequate supply of safe water is a basic human need.

Clearly, ESCWA member countries have different perspectives and priorities regarding water quality than other regions of the world. In some regions, industrial water use may account for 40 per cent of total water use, while in the ESCWA region, industry seldom accounts for more than 5 per cent of total use. Agriculture is frequently a large consumer of water in the ESCWA region because of the need to support irrigation. These significant differences in water use between developed countries and ESCWA member countries have major implications for the way in which ESCWA member States develop their own water quality strategies. Because industrial water demand in this region tends to be less important than drinking water and management plans for sanitation issues, institution and financial and human resources tend not to be directed at industrial pollution problems as they are in some other regions, such as the ECE region.

The United Nations, through numerous programmes and conferences, has focused attention on the issues pertinent to water quality management in terms of its assessment, criteria and guidelines. The United Nations Water Conference in Mar del Plata Argentina, 1977 produced an action plan for meeting the goal of providing safe drinking water and sanitation for all human settlements by the year 1990 and beyond.

Nearly 80 per cent of the ESCWA region's population have reasonable access to safe drinking water and around 50 per cent have access to sanitation facilities.[1]

Pollution remains a major concern in water quality management. In the ESCWA region, additional pollutant loads are attributed to inadequate and/or malfunctioning municipal, package, and individual wastewater treatment systems. In addition, growth in urban areas commonly exceeds the design capacity of the treatment facility. Industrial wastes are now significant pollutants in the region. They can be traced to agro-industries (such as brewing, slaughtering and tanning), petrochemical and gas production in Iraq, Saudi Arabia and Egypt.

In addition to direct discharge, non-point contamination from agricultural chemicals is another pollution problem, affecting both surface and groundwater. In the ESCWA region, there appears to have been a marked increase in eutrophication from pesticides, herbicides and fertilizers. Health and/or the economy are being affected by environmental pollution problems. As much as 80 per cent of the ESCWA region's diseases is directly or indirectly attributable to water. Together, water shortages and contamination are believed to cause human death. Remedial actions are easier to perceive than to implement. They range from planning and institutional support to costly physical removal of hazardous wastes from dump sites and contaminants from groundwater. Planning towards improvement of water supply quality increased during the 1980s, and apparently most of ESCWA member countries realized that development cannot occur unless water resources are monitered and protected.

The present technical publication on the assessment of water quality in the ESCWA region has been prepared as a direct response to the recommendations of the Dublin and Rio Conferences concerning water management and sustainable development. These conferences asserted that:

(a) Adequate supplies of water of good quality must be maintained for the entire population of the planet, while preserving the hydrological, biological and chemical functions of ecosystems;

(b) Technologies must be developed, including the improvement of appropriate technology, to fully utilize limited water resources and to safeguard those resources against pollution.

C. METHODOLOGY

Basically, there are two approaches to reconsidering water practices: increasing the supply of usable water or/and reducing the demand for water. Supply and demand, as well as delivery, have to be considered as an integral system. There are many possibilities for increasing supply. One possibility is to manage rationally the quality of water: the focus of the present publication. Usually, water users tend to overuse when water is available. This can lead to problems such as excessive groundwater pumping, deterioration of water quality, soil logging and salinity.

Rational management of water quality by using new technology will lead to the use of the reserves of brackish water and many surface waters—estuaries, coastal lagoons, land-locked lakes and irrigation return flows, which contain fairly large amounts of salts. If saline water could be used for irrigation, more land

[1] "Reasonable access to safe water" is defined by the World Health Organization as piped to a housing unit or a public standpipe within 200 metres. In rural areas, it implies that a disproportionate part of the day need not be spent in fetching. "Safe water" includes treated surface water and untreated water from protected springs, wells and sanitary wells. "Access to sanitation facilities" is defined as being served by a public sewer or by household systems, such as pit privies, pan-flush latrines, septic tanks and commercial toilets.

could be cultivated and the non-saline water could be used for human consumption, thereby reducing the need for the expensive desalination schemes now contemplated for supplying urban areas.

Hence, it is recognized that attention should be given to water quality management. However, resource constraints facing ESCWA member countries have often prevented them from dealing with water quality as a priority issue. In the present publication, all water uses will be considered when assessing water quality issues, including industrial, agricultural and domestic water. Lakes, estuaries and other water sources are included as well, as is a focus on the environmental impact and resultant pollution.

The following six chapters are designed to help water managers by sorting out all problems associated with the assessment of water quality in the region, to economically and efficiently develop and allocate water resources in the region to various uses. Such uses are drinking, household and municipal purposes, agriculture and irrigation, industry and recreation.

The present publication will manifest the current status and practices related to water quality in the region. The study also focuses on water quality issues and control, whence it considers the question of water quality monitoring, the reality of this pivotal activity in the countries of the region, and the requirements for a monitoring programme. The study then presents an overview of water remediation and water pollution prevention, two of the most needed activities in the region. The current problem of management of water quality will be delineated. In conclusion, the study makes some tentative remarks on possible paths to be followed in search of solutions for water quality problems in the region. Details have to be worked out in the light of some of the results reached in the text, and others that can be obtained from in-depth surveys and field studies. Recommendations of the study are directed towards adaptation of proper measures to ensure better water quality norms according to the requirements for the sustainable socio-economic development of the countries of the ESCWA region.

I. FOCUS ON THE CHARACTERISTICS OF WATER QUALITY

In the context of the Mar del Plata Action Plan and UNCED (Agenda 21, Chapter 18), an assessment of water resources in terms of quantity and quality, which are inseparable, is needed in order to meet the excessive demand for different water uses. The difficult realities of competition for scarce resources and disagreements over the degree to which goals can or should be reached raise many inextricably interrelated issues of the multidimensional spectrum of environment and health. These issues deal with water pollution (point[2] and non-point[3]) and health erosion, deforestation and sedimentation, salination, water reuse and conservation, and adequacy of institutional arrangements. Additional production of water resources requires addressing such issues as sea-water intrusion which results from the over-pumping of ground water from aquifers located along the sea-shores in most ESCWA member countries. Fresh ground water reservoirs are being depleted and sea water is advancing into ground-water basins at a high rate, contaminating the fresh ground and creating brackish and highly saline ground-water aquifers with a salinity in excess of 20,000 milligrams/litre (mg/l), which renders it unsuitable for almost every use. This adversely affects the environment, irrigation projects (which extend to more than 10 kilometres inland in some Gulf States) and drinking water schemes in most ESCWA member countries.

In the ESCWA region, two types of conventional water resources are recognized: surface and ground water.

A. SURFACE WATER IN THE NORTHERN PART OF THE ESCWA REGION

(Egypt, Iraq, Jordan, Lebanon, the West Bank and Gaza Strip and the Syrian Arab Republic)

With the exception of the Nile river, which flows from tropical lakes, and the Tigris and Euphrates rivers, which flow from semi-humid central Turkey, there are only a few small rivers in the Syrian Arab Republic, Lebanon and Jordan. Numerous seasonal wadis prevail in most of the ESCWA region. They are characterized by sharp changes in their water levels, with periods of drought sometimes exceeding eight months and even several years in some areas. The following is a brief description of the water quality and associated problems of major rivers in this part of the ESCWA region.

(1) The Nile

(a) Hydrological set-up:

- The Nile river is Egypt's sole source of surface water, nearly 85 per cent of which originates from the Ethiopian highlands. It consists of a flood plain and the Nile Delta;
- The Nile river is 6,690 km long and flows from south to north with a catchment area of 3,007,000 km^2 which is shared by eight countries (Egypt, the Sudan, Ethiopia, Uganda, Kenya, Tanzania, Rwanda, and Zaire);

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[2] Point sources are those from which pollutants are discharged into water at identifiable and discreet points.

[3] Non-point sources are those involving numerous sites throughout a given ara from which pollutants are transported to surface and groundwater through many discreet routes.

- Main sources are found in Ethiopia (60 per cent of which flows through Sobat, Blue Nile and Atbra, mainly in summer) and the countries around Lake Victoria (White Nile);

- The hydrographic and hydrological characteristics vary greatly over the Nile basin. Rainfall in the headwater area is abundant (2000 mm/yr) though seasonal, but starting from the Sudan the river runs through an arid zone;

- The annual river discharge is 99.5 bcm (4.3 per cent of the annual runoff). The average annual discharge for 95 years is estimated at 91.2 bcm at Aswan (1, 2, 3, 4).

(b) Water use and associated water quality issues:

- Historically, agriculture has been the dominant sector in the Egyptian economy. In the late 1950s and early 1960s, the Egyptian economy expanded to include industrial development;

- Water resources, dominated by agricultural consumption, are characterized by a rigid water distribution system extending over 1,000 km with 30,000 km of secondary canals, and the continuous threat of sea-water intrusion into the Nile Delta;

- The Aswan High Dam, constructed in 1968, has a live storage capacity of 130 billion cubic metres (bcm);

- The Nile water agreement of 1959 with the Sudan clearly defines the division of the river water, based on the average flow of 84 bcm. The average annual evaporation have been estimated at 10 bcm, leaving a net usable annual flow of 74 bcm. Of this, 55.5 bcm were allocated to Egypt and 18.5 bcm to the Sudan;

- Agricultural use is estimated at 88 per cent of 59 bcm (4.5 bcm annual safe extraction of ground water), industrial use 5 per cent, and municipal use 7 per cent;

- Projections indicate that total water use will increase to 69.4 bcm by the year 2000. The share of water allocated to the agricultural and municipal sectors will essentially remain the same, whereas the amount allocated to the industrial sector will increase, with navigational use declining substantially;

- Studies indicate that the per capita share of water in Egypt will decrease substantially;

- The Nile river headwaters are generally of high quality and are adequate for different purposes;

- Contaminated drainage water in the Nile Delta, owing to the increased use of agrochemicals and pesticides, is affecting the quality of both surface and shallow ground water. Significant quantities of used pesticides pass from agriculture drainage into the Nile;

- The inability of the industrial sector to meet the requirements of Law No. 42 (chapter II) because of the costly treatment processes stipulated by the law has resulted in the discharge of inadequately treated industrial effluents into surface water or municipal sewer systems;

- Application of nitrogen, phosphate and potash fertilizers increased nearly fourfold between 1960 and 1988. Ground water is used extensively for drinking purposes and is more vulnerable than surface water to fertilizers and pesticides contaminations;

- The seventh of a series of technical reports prepared to document the work done for the first phase of the Master Plan for Water Resources Development and Use (EGY/024) states that:

  "The overall quality of water in the Nile system is good for all purposes. There are particular locations where local pollution loads temporarily exceed the ability of the Nile to assimilate or dilute. But for the most part the quality of water in the Nile system from the Sudan border to Cairo can still be described as "good". Downstream from Cairo, in both the Rosetta and Damietta branches, deterioration does occur, but water is generally of good quality. The quality in the fresh water canal system is also good although there is more variation both spatially and temporarily. The quality in the drains varies from good to polluted" (1, 2, 3, 5).

According to the same report, the water quality in Lake Nasser behind Aswan Dam are as follows:

January 1980	167 ppm (40 km upstream) 143 ppm (400 km upstream)
May 1980	220 ppm (40 km upstream) 192 ppm (400 km upstream)

Other chemical characteristics of the water quality of the lake are indicated in table 1:

TABLE 1. CHEMICAL ANALYSIS OF THE WATER OF LAKE NASSER

	High	Low	Remarks
Surface pH	8.8	8.2	Lower values found at depth
Bicarbonate (mg/l)	146	52	Surface values 1971/1976
Sulphate (mg/l)	16	4	Surface values 1975/1977
Chloride (mg/l)	24	3	Surface values 1974/1977
Phosphate (mg/l)	0.24	0.11	Surface values 1966 and 1977
Nitrate nitrogen (mg/l)	3.0	0.5	Surface values 1976 and 1977
Sodium (mg/l)	27.8	6.2	Surface values 1974 to 1976
Potassium (mg/l)	9.0	1.9	Surface values 1974 to 1976
Calcium (mg/l)	27.5	14.3	Surface values 1974 to 1976
Magnesium (mg/l)	13.5	4.5	Surface values 1974 to 1976

Source: UNDP/Egypt, First Phase of the Master Water Resources Development and Use, "Water quality", technical paper No. 7, UNDP/EGY/73/024, March 1981.

The water quality of the Nile ranges from 175-180 mg/l at Aswan to 200-210 mg/l at the Delta Barraga. The values of other chemical elements are given in table 2:

(2) The Euphrates

(a) Hydrological set-up:

- The longest river in Western Asia, it flows from headwater in southeastern Turkey, where the average annual rainfall is 1000 mm;

- The Euphrates flows down the steep slopes of the Tartus mountains and enters the eastern plains of the Syrian Arab Republic where annual rainfall is 200 mm;

- Owing to an extremely arid climate, the cultivated lands on the Mesopotamian alluvials suffer from salt accumulation and waterlogging problems;

- The watershed of the Euphrates is situated in Iraq, the Syrian Arab Republic and Turkey and occupies an area of 233,000 km^2 of which 63,874 lies in Turkey (Furat and Murrad), 1,043 in the Syrian Arab Republic (the Khabour, Sajour and Bleikh branches), and 980 km^2 in Iraq, the balance being in Saudi Arabia;

TABLE 2. CHEMICAL CONCENTRATIONS AT DIFFERENT LOCATIONS

	1976	1977	Remarks
PH	8.2	8.1	Rises quarterly from a low of 7.2 High Dam and let to 8.0 at 150 km downstream
D.O	7.3	9.2	Rises quarterly from a low of 4.5 at Aswan to 8.0 at 50 km downstream
Total carbonate	71	83	In this reach of the river, serious water quality problems exist only at Helwan and Cairo where phenols, oil, grease and heavy metals in the bottom sediments have been reported at above normal levels
Sulphate (SO_4)	12	11	
Chloride (Cl)	14	19	
Phosphate (PO_4)	0.7	0.2	
Nitrate	3	4	
Sodium	24	27	
Potassium	20	28	
Magnesium	9	17	

Source: UNDP/Egypt, First Phase of the Master Water Resources Development and Use, "Water quality", technical paper No. 7, UNDP/EGY/73/024, March 1981.

- 88 per cent of the mean annual flow is generated in Turkey and most of the remainder within the Syrian Arab Republic;

- Estimates of the river's flow show that the total average natural annual flow at Hitt (Iraq) is about 33 bcm. Of this, around 31 bcm/yr originates as surface flow in Turkey and another 2 bcm/yr are added in the Syrian Arab Republic;

- After joining Khabour, 100 km downstream, the Euphrates enters Iraq;

- The Euphrates is joined by the Tigris just above Basra, 100 km from the head of the Gulf, and together they form the Shatt-al-Arab (1, 3, 4).

(b) Water use/associated water quality issues:

- Turkey uses the upper reaches of the Euphrates primarily for the generation of electricity. This is currently changing as Turkey plans to make greater use of the river's water for irrigation purposes. The Attaturk Dam has been completed and the reservoir behind has been filling since 1991. This is part of Great Anatolium Project (GAP), which will eventually irrigate 1 million hectares;

- The waters of the Euphrates and its major tributary, the Khabour, are mainly used for agricultural purposes in the Syrian Arab Republic. It is estimated that the Tabqa Dam will provide irrigation for over 600,000 hectares, and further development of the Khabour will bring another 400,000 hectares under irrigation;

- Continuous use of Euphrates water for irrigation will degrade the water quality of the river, which will affect adversely the use of the water in the downstream countries;

- Increased use by upstream countries will reduce the flow in the river as a result of irrigation, that is, consumptive use. Additionally, the irrigation water that is returned will degrade the quality and further aggravate the water quality problem;

- The Hindia Dam in Iraq (1913) represents earlier development on the Euphrates. Its purpose was to divert water to irrigation canals. In the 1950s, a second dam was built at Ramadi which was designed for flood control and permitted flood waters to be impounded in lake Habbaniah and the Abu Dibis Depression. The soil of the depression proved saline, resulting in the degradation of water quality and the scrapping of the irrigation plan. A third dam was built at Haditheh in 1985;

- In the light of the proposed development schemes of each of the three users of the Euphrates, the waters of the river will be almost completely utilized. Successful completion of all the planned projects may lead to a very small surplus of water in average flow years and severe shortages during droughts accompanied by severe deterioration of water quality;

- The headwaters of the Euphrates river provide reputedly high-quality water (Turkey). Data are not available to determine this, although it is stated that irrigation waters used in the lower part of the Euphrates average 300 to 500 ppm salinity and that the river water in the south may reach 600 ppm;

- It has also been reported that the salinity of the Euphrates averages about 250 to 445 ppm. Regardless, the use of the water for irrigation purposes upstream attests to its quality. In the estuary region located south of Basra, the salinity levels are naturally much higher. This is especially true at high tide in the autumn, when the flow is at its lowest level. During such periods, the salinity is typically over 5,000 ppm;

- The lower part of the Euphrates is naturally prone to salinization. This results from a combination of poor drainage, centuries of irrigation, and natural soil factors. Edaphic factors in the lower basin contribute to a reduction in water quality as the river moves downstream. The flooding of the Abu Dibis depression in the 1950s resulted in degraded water because of the rapid evaporation rate and the high salt content in the soils of the depression;

- Turkey, the Syrian Arab Republic and Iraq have extensive plans for further development of the Euphrates. These plans are expected to mature and be implemented over the next 20 years, aiming at increased irrigation and an expanded industrial base as their populations grow. An unintended result will be the certain degradation of the quality of the water in the river's lower reaches, which will render the water progressively less fit for use by Iraq (1, 2, 4).

(3) The Tigris

(a) Hydrological set-up:

- The Tigris flows from the headwaters in Turkey. Both the Tigris and the Euphrates join to form Shatt-al-Arab about 200 km (river kilometres) from the Gulf;

- Tigris has several major tributaries draining the Zagrous mountains along the Iraq-Iran border;

- Rain falls mostly in winter, most of it in the mountains of Turkey and the Zagrous mountains. Average annual rainfall varies from less than 100 mm in Iraq to 1000-1600 mm or more in the mountain headwaters. Most flow generates from winter rains and melted snow in spring;

- The catchment area of the Tigris is 171,800 km^2;

- Flows vary from one year to another. Low record flows (since 1920) are reputedly less than 1/3 of the annual average;

- The Tigris during floods can carry a 20,000 ppm silt load (five times that of the Nile flood load) (1, 2, 3).

(b) Water use/associated water quality issues:

- The Tigris irrigates more than 2 million hectares in Iraq, while the Syrian Arab Republic and Turkey have much less irrigation, but both have future irrigation projects;

- Several dams have been constructed on the Tigris and its tributaries in the last 10 years for hydropower, flood flow regulation, and irrigation;

- A very important feature is a linkage of the Tigris to the Euphrates via the Tharthar depression to alleviate expected shortages on the Euphrates as well as flooding along its most intensely irrigated lands, and to drain salts from the area between the two rivers;

- In addition, Iraq has constructed the main Outfall Drain, 500 km long, to drain about 2 million hectares of irrigation waters which drain into Shatt-al-Arab near Basra;

- During modest flows, the water needs for much of Iraq's irrigation will not be met, especially if Turkey implements all water projects on the Tigris;

- Salinity reaches 7,000 ppm in the Mesopotamian plain and 30,000 ppm near Basra, while in the high quality Tigris headwaters salinity is on the order of 300 to 500 ppm;

- The lower reaches of the Tigris cannot be used for domestic water purposes because of high salinity. The water quality of river branches in the vicinity of Basra is very poor as a result of untreated sewage disposal coupled with rather limited dilution;

- Haur Hammar is a substantial area of reasonably fresh water situated at the upper end of the Shatt-al-Arab (Basra). The quality of this water relies on freshwater flows from the less saline Tigris. Maintaining low salinity levels in Haur Hammar is important, since the Shatt-al-Arab relies on Haur Hammar as an indirect source of freshwater to irrigate the substantial areas of date plantations along its banks;

- Development works in the upper and middle reaches of the Tigris have reduced the water reaching it. Flows from the Euphrates and Tigris-Euphrates Outfall Drain are comparatively slimy;

- Flows into Shatt-al-Arab are expected to decrease because of the increased irrigated withdrawals upstream on the Tigris and Euphrates (Turkey and the Syrian Arab Republic, where water quality can reach 200 ppm) if most water resources projects planned are completed, very little water will reach the estuary that has been used for agriculture;

- Untreated sewage causes waterborne diseases, such as cholera, and schistosomiasis has been reported;

- The chemical industry discharges water into the Tigris;

- Poor water quality would have a substantial impact on the irrigation process;

- Deteriorating water quality may substantially affect important fisheries and fish migration (1, 2, 3, 4).

(4) Orontes (Al-Asi) River

(a) Hydrological set-up:

- The Orontes originates in central Lebanon and flows northward through Lebanon for 40 km and 471 km through the Syrian Arab Republic;

- The Orontes crosses the Ghab Valley (60 km x 12 km), once a swampy depression, and flows through Turkey for about 60 km of its length, turning westward and emptying into the Mediterranean Sea;

- Three quarters of the Orontes watershed (total is 16,900 km^2) area is in the Syrian Arab Republic;

- Rain falls in winter, ranging from 1000-1500 mm annually in the headwater (Lebanon mountains), while in the Ghab Valley average annual rainfall is 700 mm;

- Mean discharge at Cheizar (at the head of the Ghab Valley) is about 0.79 bcm/yr, and near Antioch it is 1.1 bcm/yr;

- The Afrin River (originates in Turkey, flows into the Syrian Arab Republic and then returns to Turkey) contributes 0.25 bcm/yr upstream of Antioch;

- Flows vary markedly from winter to spring to late summer, average maximum discharge exceeds 400 m^3/sec in February and March but drops to 10 m^3/sec in late summer;

- The Orontes flows are regulated by dams that provide for irrigation, flood regulation and hydropower. The Rastum Dam, built on the Orontes, has a capacity of 0.25 bcm capacity and the Mahradeh has a capacity of 0.065 bcm (2, 4).

(b) Water use/associated water quality issues:

- The Orontes is mainly used to irrigate the Ghab Valley, where irrigated agriculture withdraws 0.58 bcm/yr from the surface water and 0.105 bcm/yr from the groundwater;

- Agricultural products are mainly, cereal, cotton and fruits;

- Orontes water is not used for municipal water supplies because of problems related to sewage effluent;

- Industrial use is relatively high;

- Smaller agricultural regions are extending along the Orontes upstream from Hama and in Lebanon;

- The Rastum and Muhradeh dams provide electricity in the entire region between Homs and Hama;

- Contamination may exist owing to domestic and industrial effluent;

- Untreated sewage is emptied into rivers and streams, larger cities, such as Homs and Hama, have fairly comprehensive sewage systems;

- Waterborne diseases are endemic, primarily along lower reaches (typhoid, cholera and dysentery);

- Low water quality has a negative impact (low flows) on fisheries in the river, particularly in dry seasons, i.e. low flows (2, 4).

TABLE 3. CHEMICAL ANALYSIS REFLECTING WATER QUALITY PROBLEMS

Location	Date	Temperature °C	pH	Conductivity µmos/cm	D.O.	Cl	NH_4	BOD	S.S.	PO_4	Na	K	NO_3
Al-Bani Mendo	13.1.94	14	8.15	385	7.6	25	-	2 2.12	17	-	6.0	1.4	
	1.11.86	15.5	8.12	326	9.0	25	0.2		5.5	-			
Al-Dhahriya	12.1.94	11	-	740	2	75	-	40	42	-	54.5	11.6	
Hammat Al-Sheikh Issa	2.11.91	14	-	-	-	77.5	0.4	1	23	-	56.0	6.6	
Jisr Trablus	4.1.94	12	7.95	425	4.3	50		24.0	15	-	17.5	2.6	-
	1.11.86	18.63	8	615	5.12	62.4	9.71	13.5	59	10.82	-	-	24.25

Source: Data obtained from a report submitted by ESCWA regional advisers on industrial wastes in the Orontes.

(5) Litani river

(a) Hydrological set-up:

- The Litani is entirely situated within Lebanon;

- Litani rises in the Bekaa' Valley and flows south through the valley between the Lebanon mountains and the Anti-Lebanon mountains before turning west and flowing towards the Mediterranean Sea;

- The Litani basin area is 1940 km^2 and 145 km long;

- Most of the rain falls during the period from December to February. It varies markedly from year to year and ranges from 500 mm in the Bekaa' Valley to 1000-1600 mm in the heights of the basin;

- The average annual natural flow is 0.92 bcm and varies from year to year. Streamflow in the lower Litani below Qirawan Reservoir may recharge aquifers that feed the Hasbani River;

- Litani flows are regulated by the Qirawan Reservoir, which has a storage capacity of 0.23 bcm, and are used for irrigation, hydropower and water supply (1, 2, 4).

(b) Water use/associated water quality issues:

- The largest single withdrawal from the river is the diversion to the Awali river for power generation for Beirut and other coastal cities. Approximately 40 per cent of the total electricity production in Lebanon comes from the Litani's water directly or through the Awali River System (Markaba Tunnel Diversions. The diversion is also used for coastal orchard irrigation);

- Beirut has experienced water shortages during the summer months, and a plan to divert water from Awali River System to augment the city's water supplies is an alternative for the future. This may increase the current amount diverted from the Litani;

- At present there are two major irrigation projects in the basin, both of which are supplied from the Qairawan Reservoir. The two projects are the Bekaa' Valley, averaging 0.12 bcm/yr withdrawal, and the Qasimiyah project, averaging 0.077 bcm/yr withdrawal;

- Currently about half of the runoff produced in the basin is used. However, along the river, especially in the southern Lebanon downstream from Beaufort Castle, there is very little flow late in the summer or none at all;

- Villages in south Lebanon utilize unknown flows along the lower Litani;

- The Litani river is identified as a high quality water source averaging 20 ppm salinity, which renders the water usable for irrigating any crop;

- Return flows from irrigation in the Bekaa' Valley may affect salinity and create problems with toxic elements derived from pesticides, but little research has been done;

- The major sources of pollution of the Litani River and its tributaries, including Lake Qaroun, include wastes from industries (sugar factory, poultry farms, wineries, cluster of tanneries);

- Untreated municipal sewage is reported to be discharged into the river;

- Table 4, which dates back to 1970-1972, shows that:

  - There seems to be declining trend in mineral contents towards the downstream section of the river;

  - In Lake Qaroun, the water quality of the river arises principally from the organic contaminants (BOD), which reflects changes in certain physio-chemical components caused by the photosynthetic activity of the algae (PH and DO), and the enhancement of sedimentation of suspended matter as indicated by the drop in turbidity;

  - Wastes discharged into the lake may be the cause of the rise in BOD;

  - There is uncontrolled disposal of industrial wastes of chromium and lead (2, 4, 6).

(6) The Jordan River

(a) Hydrological set-up:

- The Jordan River flows south from Lebanon and the Syrian Arab Republic to Lake Tiberias and then to the Dead Sea between the West Bank and Jordan. The river is 360 km long, and its catchment area is 18,300 km^2;

- The Yarmouk River, the main tributary, flows between the Syrian Arab Republic and Jordan for 40 km before flowing into the Jordan River 10 km below Lake Tiberias. Its basin area is 7,250 km^2, 80 per cent of which is in the Syrian Arab Republic;

- The Northern basin has a Mediterranean climate. Average annual rainfall in the upper Jordan and Lake Tiberias are 1600 and 800 mm respectively, while the average annual rainfall over the Yarmouk basin is around 360 mm;

- The upper Jordan is fed by springs of relatively steady flow. The Hasbani River is fed by springs in Lebanon, and the Banias River is fed mostly from a Syrian spring;

- Winter rainfall generates 50 per cent of Jordan River flows. Most runoff (70 per cent) originates in the Syrian Arab Republic and Jordan. The upper Jordan River averages 0.56 bcm/yr as a natural flow;

- The Yarmouk River discharges about 0.4 bcm/yr as a natural flow;

- In the lower Jordan Valley, below Lake Tiberias, runoff is about 0.7 bcm/yr which reaches the Dead Sea;

- Winter rainfall over the West Bank recharges three important aquifers that underlie the western part of the West Bank (1, 2, 3, 4).

(b) Water use/associated water quality issues:

- Agriculture is the main economic activity and depends on Jordan River. Irrigation is the main water user;

- The Jordan River system satisfies about 50 per cent of water demand in some parts of the Jordan Valley basin. Lebanon and the Syrian Arab Republic are the main users;

- About 0.1 bcm/yr are used to irrigate the Yarmouk triangle by pumping water to Lake Tiberias and the Beisan plain from the Rottenburg reservoir at the junction of the Yarmouk and Jordan rivers south of Lake Tiberias. In addition, all the water from the tributaries of the Jordan River north of Lake Tiberias are used by pumping most of it through the national water carrier to the coastal plain and the Negev Desert;

- The water utilization and diversion projects have reduced by half the flow of the Yarmouk River as it enters the Jordan Valley;

TABLE 4. SUMMARY OF ANALYTICAL DATA FOR LITANI RIVER

(Mean values, 1970-1972)

Characteristics[(b)]	Upstream Section	Qatroun Lake	Downstream Section	Overall Mean
pH	8.06	8.26	7.98	9.03
Oxygen, dissolved	9.2	10.3	10.00	9.50
B.O.D.	5.8	6.4	4.1	5.2
Chloride (Cl)	75.3	30.0	18.6	49.3
Hardness, total ($CaCO_3$)	246.6	252.2	179.8	218
Hardness, calcium ($CaCO_3$)	193.4	202.5	139.9	170.6
Hardness, magnesium ($CaCO_3$)	53.2	50.0	50.0	52.2
Alkalinity, total ($CaCO_3$)	178.3	177.5	161.1	174
Flouride (F)	-	-	0.17	0.17
Chromium (Cr^{+6})	-	0.11 6	0.09 3	0.105
Lead (Pb)	-	-	0.25	0.25
Sulfate (SO_4)	-	8.7	14.7	13.2
Sp. Conductance, μ mhos/cm at 25°C	470	298	256	375
Residue, total	-	-	261	261
Residue, suspended	-	-	9.7	9.7
Turbidity, J.T.U.	46.6	17.5	39.3	44
Silica (SiO_2)	-	-	4.9	4.9
Coliform count (MPN/100 ml)	>150	>169	>95	>124

Source: A. Aera and C.J. Inglessis, "Potable water resources", Council for Development and Reconstruction, Republic of Lebanon, American University of Beirut, March 1978.

- As for the Syrian Arab Republic, it is using its share, which includes the water of the high altitude springs which feed the Yarmouk. The total annual discharge of water from these springs is about 0.09 bcm/yr;

- The Syrian Arab Republic has built in the upper Yarmouk Basin a number of small and medium-sized dams (21 dams) with a total storage capacity of about 0.1 bcm/yr;

- Jordan is currently diverting about 0.11 bcm of water per annum to the King Abdallah Canal for irrigation purposes in the Jordan Valley;

- The Hasbani river originates in Lebanon and is a tributary of the Jordan River. Its annual discharge was estimated at about 35 million m^3 (2, 4).

(c) Water quality and relevant environmental issues:

- Jordan River headwaters are generally of high quality and sufficient for agricultural, domestic and most industrial uses;

- The Yarmouk River salinity reaches 100 ppm, while the Dan, Hasbani and Banias rivers' water quality ranges from 15 to 20 ppm;

- Lake Tiberias has much higher salinity (250-400 ppm);

- The headwaters of the Jordan are generally of high quality. The three tributaries of the upper Jordan—the Dan, Hisbani and Banias—have a salinity of about 20 ppm, clearly low enough to satisfy most uses. The salinity of the Yarmouk River is also reasonably low, reportedly 100 ppm. The salinity of the lower portion of the Jordan River system becomes progressively greater below the entry of the upper Jordan into Lake Tiberias;

- Several natural sources render Lake Tiberias water saline up to about 350 ppm, too high for some sensitive crops, most notably the citrus fruits that are economically important in this region. Much of the salt results from the inflow of salty subterranean springs. As the Jordan proceeds down into the Rift Valley towards the Dead Sea, it becomes saltier, reaching several thousand parts per million by the Allenby Bridge near Jericho;

- The salinity of the Jordan River system reaches 25 per cent (250,000 ppm) in the Dead Sea, a level approximately seven times that of the ocean. Naturally, this is too high to support plant or animal life, although certain minerals, especially bromine and potash, can be extracted by (solar) evaporative processes;

- Although the greatest water quality concern in this region is salinity and its impact on the agricultural fitness of the water, there has been some concern recently about other water quality issues (1, 3).

B. SURFACE WATER POTENTIAL AND QUALITY IN THE ARABIAN PENINSULA (BAHRAIN, KUWAIT, OMAN, QATAR, SAUDI ARABIA, UNITED ARAB EMIRATES, YEMEN)

1. Description and hydrology

Surface water in the Arabian Peninsula is usually produced in small amounts owing to insufficient and infrequent amounts of rainfall. In the northern, central and eastern parts of Saudi Arabia, most of Kuwait, Bahrain, Qatar and the northern part of the United Arab Emirates, surface water is generally unavailable. Areas with surface water potential are southwestern Saudi Arabia, most of Yemen (the mountainous region), the southern part of the United Arab Emirates and the northern and southern parts of Oman. Ephemeral flows occur in response to localized storms which constitute the main source of groundwater recharge to shallow top aquifers (alluvials). Most of the surface water over most of the peninsula occurs in the form of flash floods, and its volume is estimated at 6.8 bcm. The annual runoff volume produced in southwestern Saudi Arabia and Yemen is estimated to be 0.45 bcm and 2.1 bcm, respectively. The national totals for Saudi Arabia and Yemen are estimated at 2.23 bcm and 3.5 bcm, respectively. Amounts of surface water available in Oman and the United Arab Emirates were estimated at

0.92 bcm and 0.15 bcm, respectively. The remaining countries have only negligible amounts of surface water. Surface water volumes, as well as other water resources components are shown in table 5 (7).

2. Water use/associated water quality issues:

Surface water in the Arabian Peninsula is utilized for flood irrigation using spreading basins, and recharge of the top aquifers is achieved through natural flow processes or from impoundment of water behind dams of various sizes that are usually located in the downstream portions of the basin. Rainfed farming is practised on step terraces (as in Saudi Arabia and Yemen) built on the steep slopes of many headwater catchments. Dams with limited storage capacity provide flood control and groundwater recharge as well as irrigation water for the mountainous areas.

- Water quality within the dam reservoirs and surface water of the Arabian Peninsula is affected by what occurs upstream. Quality may be affected by salt accumulation, eutrophication from weeds and biomass decay, turbidity and pollution from agricultural, municipal and industrial wastes;

- Because of high soil salinity and evaporation in the Arabian Peninsula, surface water may become highly saline, and its use for irrigation and recharge purposes is therefore limited;

- Trapped sediment in the reservoir does provide better quality water to downstream areas, with less suspended matter;

- Problems also can stem from irrigated areas upstream, with aquifers becoming polluted from agricultural chemicals and sewage carried in the drainage water;

- Uncontrolled use of pesticides and herbicides and lack of adequate sewage networks in many villages and towns often result in severe pollution of surface water and water stored behind dams;

- The establishment of reservoirs and associated water management facilities such as canals and ditches can create conditions that foster and spread water-borne diseases. Prevention is essential, since treatment to eliminate most disease vectors is usually impossible or very costly once they are established;

- The impounding of water behind large dams, particularly where the reservoir area is large, has resulted in increased problems with mosquitos and bacteria, resulting in localized health problems. Recent efforts by health agencies to combat water-borne diseases have alleviated these problems;

- In some countries of the Arabian Peninsula, the operation of flood control dams causes great fluctuations in water levels behind the dam. This limits the use of the land that is located between the high- and low-water levels. In many instances flood control dams are economically justified by claims that they will provide recreational benefits which include not only the use of the reservoir itself but also the adjacent land. Fluctuations in the water level may reduce the recreational potential by causing extensive landsliding around the shoreline and limiting accessibility, thereby lowering the overall aesthetic quality of the lake;

- In general, an environmental impact assessment is not a requirement for implementing water development projects in the countries of the Arabian Peninsula;

TABLE 5. WATER RESOURCES OF THE ARABIAN PENINSULA (1992)

Country (1)	Area (km^2) (2)	Annual rainfall (mm) (3)	Annual evaporation (mm) (4)	Runoff (10^6 m^3) (5)	Shallow groundwater reserve (10^6 m^3) (6)	Ground-water recharge (10^6 m^3) (7)	Ground-water use (10^6 m^3) (8)	Desali-nation (10^6 m^3) (9)	Waste-water reuse (10^6 m^3) (10)
Bahrain	652	70	1.650-2.050	0.20	182	-	80	240	83
Kuwait	17.818	70	1.900-3.500	0.10	182	-	80	240	83
Oman	300.000	71	1.900-3.000	918	10.500	550	645	32	10.5
Qatar	11.610	67	2.00-2.700	1.35	2.500	45	144	83	23
Saudi Arabia	2.149.690	75	3.500-4.500	2.230	84.000	3.850	14.430	795	217
United Arab Emirates	77.700	89	3.900-4.050	150	20.000	125	900	342	62
Yemen	550.000	122	1.900-3.500	3.500	13.500	1.550	1.200	9	6
TOTAL	3.107.470	-	-	6.800	130.772	6.220	17.559	1.557	433

Source: M.J. Abdulrazzak, "Water supplies versus demand in countries of Arabian Peninsula", Journal of Water Resources Planning and Management, May/June 1995/227.

- There is a need to develop environmental impact regulations for use in future surface water dam projects. Evaluation should include a detailed assessment of the environmental impacts associated with these projects, including those on water quality irrigation, flood control, natural vegetation and wildlife, erosion and sedimentation, and populations and relocation, as well as on the economic well-being and social welfare of the inhabitants who would be affected (7, 8).

C. GROUNDWATER QUALITY IN THE ESCWA REGION

The region for which information on groundwater quality is evaluated covers the Arabian Peninsula, the Fertile Crescent area (Iraq, the Syrian Arab Republic, Jordan, Lebanon and the West Bank and Gaza Strip) and Egypt. It includes different morphologic-climatic provinces:

- The western mountain ranges in Jordan, Lebanon and the Syrian Arab Republic, which are characterized by a Mediterranean-type climate comprising a rainy winter season with an average precipitation of >400 mm;

- The semi-arid to arid areas extending east of the western mountain ranges over the Syrian steppe and over most of the Arabian Peninsula, with average annual rainfall of 200 mm to <50 mm;

- Mountain ranges at the southeastern and southwestern fringes of the Arabian Peninsula in southwestern Saudi Arabia, Yemen and Oman, which receive a limited amount of monsoonal rainfall, with a mean annual precipitation of 200-600 mm.

These morphologic-climate provinces are generally characterized by different ranges of groundwater salinity, which are controlled principally by the climatic and recharge conditions.

1. Groundwater with low salinity

Groundwater with low salinity extends over: wide parts of the western mountain ranges, where the Mediterranean-type sub-humid climate and karstic aquifers create relatively favourable recharge conditions; and the highlands and the western escarpment in Yemen.

The groundwater salinity in most areas of the Syrian steppe and the Arabian Peninsula ranges from >1000 to several thousand mg/l total dissolved solids (TDS). This general increase in groundwater salinity towards the more arid regions is certainly, to a large extent, related to the climatic conditions: increasing aridity is accompanied by decreasing recharge and an increasing impact by evaporative processes.

In dry climate conditions, the main contributions to groundwater replenishment originate generally from indirect recharge while direct recharge, is often insignificant. (Direct recharge is defined as: direct vertical percolation of precipitation through the unsaturated zone; indirect recharge is defined as: percolation to the water table following surface runoff).

Inputs of dissolved substances through direct recharge are related prevailingly to atmospheric despotion and reactions in the soil zone. Indirect recharge can, particularly in arid climate conditions, transport increased concentrations of dissolved solids into the groundwater, the result of reactions at the surface over periods of several days to months: enrichment by evapotranspiration, reactions with soil carbon dioxide (CO_2), and dissolution of soluble substances.

Accordingly, groundwater in large parts of the semi-arid to arid regions is brackish to saline. The sources of the high groundwater salinity can be attributed to the following factors:

(a) Infiltrating surface water as well as near-surface groundwater is enriched in dissolved substances through evapotranspiration or leaching of salt accumulations, in particular in closed basins, but also along wadi courses;

(b) Evaporite layers or dispersed salts, which occur in wide parts of the region in Mesozoic and Cenozoic sedimentary rocks of marine or lacustrine origin, are incompletely flushed because of the limited quantity of groundwater circulation.

Some areas of Western Asian countries with very low rainfall contain groundwater resources with adequate or marginal quality for domestic use or irrigation. The hydrochemical composition and the origin of these groundwaters with different levels of salinity will be discussed in the following paragraphs (9).

The climatic conditions on the coastal plains along the Mediterranean Sea, the Red Sea, the Gulf of Oman and the Arabian Gulf range from semi-humid to arid. Groundwater salinity is dominantly influenced on the coastal plains by infiltration of surface inflow in wadis and intrusion of salt water from the sea or coastal sabkhas.

(a) Occurrence of groundwater with low salinity

In the semi-arid to arid regions (mean annual rainfall <200 mm) in Western Asia, groundwater occurrences with relatively low salinity (<1500 mg/l TDS) are found in the following aquifers:

- Paleozoic sandstone aquifers in Jordan, Saudi Arabia and western Iraq (Disi, Saq, Tabuq, Gaara sandstones);

- Karstic carbonate aquifers in the central part of the Syrian Arab Republic and in Saudi Arabia (Cretaceous limestones and dolomites at Qaryatein and Arak in the central part of the Syrian Arab Republic, Umm er Radhuma Formation in Saudi Arabia);

- Aquifers related to extended wadi systems, examples of which are:

    - Fissured Paleogene chalks and limestones in the Hamad region of the southeastern part of the Syrian Arab Republic, western Iraq and northeastern Jordan;

    - Alluvial sediments in mountainous areas of the crystalline Arabian Shield in Saudi Arabia and Yemen;

    - Pleistocene sandstones at the lower end of extended wadi systems in Kuwait;

- Alluvial sediments in the upper parts of arid coastal areas on the Red Sea and the Gulf of Oman.

Examples of major ion concentrations of groundwater samples are listed in table 6 for such aquifers in selected areas. Average values of anion concentration are shown in figure I for some examples of these aquifers.

(b) Paleozoic sandstone aquifers

Outcrops of Paleozoic sandstones extend, adjacent to the Precambrian basement of the Arabian Shield, from southern Jordan into northwest, north-central and southwest Saudi Arabia (Tabuk, Hail-Buraydah and Wadi Dawasir areas) over a distance of 1,500 km. The Cambrian to Ordovician sandstones, attributed to various stratigraphic units (Saq and Wajid Formation, Disi Group of the Rum Formation) generally contain groundwater with low salinity within and near the outcrop area.

Concentrations of Cl and SO_4 are in the range of 20-70 mg/l, HCO_3 concentrations around 100-130 mg/l. Predominant ions are Ca and HCO_3.

The concentrations of Cl and SO_4 are not much higher than those in the current rainfall and may originate mainly from atmospheric inputs somewhat concentrated through evaporation at or near the surface during the recharge process. The HCO_3 concentrations are related, apart from limited atmospheric inputs, to interaction of soil CO_2 with silica minerals or carbonate cement.

In the Disi aquifer in southern Jordan, groundwater salinity increases from 200-250 mg/l TDS near the outcrop area to 500-800 mg/l in the direction of regional groundwater flow towards the northeast and south and to high salinities in the Dead Sea area.

In Saudi Arabia, higher Cl concentrations occur in some parts of the outcrop areas where indirect recharge is created by infiltration of wadi runoff from the basement under arid conditions. The groundwater with low salinity is attributed to significant recharge between 10,000 years and 30,000 years BP.

High salinity in some pumping wells is caused locally by leakage of groundwater from overlying aquifers and by infiltration of irrigation return flow.

(c) Karstic carbonate aquifers

In the Palmyra area in the central Syrian Arab Republic, Cenomanian-Turonian limestones and dolomites constitute an aquifer which is locally exploited for domestic supply and irrigation. Groundwater salinity ranges generally between 900 and 2500 mg/l TDS. Groundwater resources with low salinity are found in limited areas, in particular at Qaryatein, 100 km west of Palmyra, and at Arak, 30 km east of Palmyra.

The Umm er Radhuma Formation constitutes one of the Saudi Arabia's most important aquifers. It consists of Paleocene-Eocene limestones and dolomites, which crop out in a strip extending from north to south over nearly 1,000 km, and 50 to 70 km wide, from the western desert of Iraq through central Saudi Arabia and into Yemen and Oman.

The low salinity groundwater in the Umm er Radhuma and in the Cenomanian-Turonian limestones and dolomites in the central Syrian Arab Republic is obviously related to significant recharge under relatively humid climate conditions. Major ion contents may originate mainly from atmospheric inputs and dissolution of rock carbonate under the influence of soil CO_2 with some enrichment of Na and Cl during the recharge process.

In the Karstic carbonate aquifers at Qaryatein in the central Syrian Arab Republic and in some parts of the Umm er Radhuma aquifer in Saudi Arabia, Cl and SO_4 concentrations are in similar ranges as in the sandstone aquifers discussed above: Cl and SI_4 concentrations between 17 and 50 mg/l, and Na, Ca and Mg concentrations between 17 and 70 mg/l.

HCO_3 concentrations, varying from 140 to 270 mg/l, can be attributed to carbonate dissolution through an impact of soil CO_2 during the recharge process. Again, groundwater ages are high according to carbon-14 data (20,000 years) and, as in the above-mentioned sandstone aquifers, the origin of these groundwaters has to be sought in recharge events during pluvial periods, while replenishment from present recharge is low.

Relatively high SO_4 concentrations of groundwater in the Cretaceous aquifer at Arak in the central Syrian Arab Republic may be related to a lithogenic source, and the low HCO_3 content may tentatively be attributed to recharge in a rather arid environment with low CO_2 production in an insignificant soil cover. The low salinity groundwater at Arak has a carbon-14 age of 20,000 to 30,000 years.

TABLE 6. EXAMPLES OF MAJOR ION CONCENTRATIONS OF GROUNDWATER SAMPLES WITH LOW SALINITY FROM DRY AREAS IN WESTERN ASIA
(MG/L)

Aquifer	Area	Ca	Mg	Na	HCO_3	SO_4	Cl
Sandstone aquifers							
Disi	South Jordan	75	12	20	105	23	33
Tabuk	Jauf	31	12	46	139	48	16 1
Tabuk	NE Saudi Arabia	59	23	51	54	49	113
Karstic carbonate aquifers							
Up.Cretac.	Qaryatein, Syrian Arab Republic	64	32	58	201	178	40
Up.Cretac.	Arak, Syrian Arab Republic	42	26	30	79	130	53
Umm er Rhaduma	Wadi El-Miyah, Saudi Arabia	69	21	51	269	62	54
Wadi aquifers							
Up.Cretac.	W. El-Miah, Syrian Arab Republic	96	43	161	209	240	22 6
Tertiary	Muqat, NE Jordan	67	35	114	282	127	13 4
Quaternary	W. Arran, Saudi Arabia	59	33	103	194	96	19 9
Quaternary	W. Fatimah, Saudi Arabia	113	18	69	192	218	12 6
Pleistocene	Raudhatain, Kuwait	88	14	113	192	216	75
		54	9	47	164	72	38
Coastal aquifers							
Quaternary	Fujayrah, United Arab Emirates	20	4	103	232	62	13 8

Sources: Hobler et al. (1991), mean values; Khouri (1982), representative analyses; ACSAD (1983), mean values; Otkun (1975), selected analysis; Jado et al. (1984), average values; KISR - files of Kuwait Institute for Scientific Research, selected analyses; MAW - files of Ministry of Agriculture and Fisheries, Dubai, selected analysis. W. Wagner, "Groundwater with low salinity in the dry region of Western Asia hydrochemical aspects." This paper was submitted to the International Conference on Water Resources Management in Arid Countries (vol. 1), Muscat, 12-16 March 1995.

In the Qaryatein area, groundwater salinity increases rapidly over short distances downstream of the springs, which discharge low-salinity groundwater, SO_4 concentrations reaching 600-1400 mg/l and Cl concentrations up to 700 mg/l. The major source of the salinity increase is the dissolution of evaporates from Pliocene basin sediments and, locally, irrigation return flow.

The occurrence of groundwater with a salinity of 380 and 430 mg/l TDS from areas at or near the outcrop of the Umm er Radhuma Formation in Wadi Miyah and Wadi al Batin. The groundwater salinity generally increases eastward in direction of the regional groundwater flow, but groundwater with a moderate salinity of 1500 mg/l TDS is found as far as 200 km east of the outcrop in the Hofuf area. The Umm er

Radhuma Formation constitutes, in the regions downstream of its outcrop, a component of a complex aquifer system of fissured carbonate rocks from the Cretaceous to the Tertiary age. It is assumed that the Umm er Radhuma Formation contains the main quantity of groundwater circulating in this aquifer system. The hydrochemical composition of the groundwater changes from bicarbonate near the Umm er Radhuma outcrop area further downstream to calcium sulphate and sodium chloride with increasing salinity. The salinity increase is probably caused by dissolution of evaporite layers particularly in the Rus Formation overlying the Umm er Radhuma Formation.

The age of the groundwater in the Umm er Radhuma Formation is estimated at 15,000 to 19,000 years.

Significant indirect recharge currently occurs as inflow of surface runoff into karst cavities in the outcrop area of the Umm er Radhuma Formation. This actual recharge produces groundwater with a salinity between 1200 and 1900 mg/l TDS, the dominant ions being Ca, Na, SO_4 and Cl. The hydrochemical composition of the current recharge appears to be different from the composition of fossil groundwater.

(d) Wadi aquifers

Fresh water occurrences related to extensive wadi systems are found in various parts of the dry regions of Western Asia, e.g. on the eastern slope of the Hamad Plateau in the Syrian Arab Republic and Iraq, in the Muqat area in northeastern Jordan, on the crystalline Arabian Shield in Saudi Arabia and in the Raudhatain area in northern Kuwait. The wadi aquifers of the Hamad region—Wadi el Miyah in the Syrian Arab Republic and Muqat area in northeastern Jordan—are composed of Paleogene fissured marly limestones and chalks.

HCO_3 concentrations of 190-280 mg/l may be considered representative for infiltrating surface water from wadi runoff in a carbonate environment. The Cl and SO_4, varying between 100 and 240 mg/l, can be attributed to contents of rain water concentrated to varying degrees by evapotranspiration at or near the surface.

The isotopic composition of groundwater in wadi aquifers in the Hamad region indicate a significant impact of recent recharge: tritium contents of up to 65 T.U. and carbon-14 values of up to 74 pmc, contrasting with the values in brackish groundwater prevailing in the Hamad region. The wadi groundwaters may be assumed to represent a mixture of recent recharge with old groundwater.

The groundwaters in wadi aquifers on the crystalline Arabian Shield have relatively low HCO_3 concentrations of around 200 mg/l, which may originate principally from the interaction of soil CO_2 with silicate minerals. Cl and SO_4 concentrations are in a general range of 100 to 220 mg/l and may be considered characteristic for indirect recharge with moderately concentrated atmospheric deposition.

Generally, low groundwater salinities occur in the upper wadi courses, where flooding from sporadic rainfall is relatively frequent. A general increase of groundwater salinity from the upper course towards lower reaches is observed in most wadi systems, but high local variations of groundwater salinity occur.

Fresh groundwater in the wadi aquifers of the Arabian Shield is generally of the NaCl type as a result of NaCl concentration through evapotranspiration and absence of carbonate rocks. The fresh groundwater in the wadi aquifers is clearly related to current present active recharge.

In the Raudhatain area in northern Kuwait, infiltration of surface runoff from extensive wadi systems into Pleistocene sands and sandstones produces fresh water lenses with low to moderate concentrations of major ions.

(e) Coastal plains

Fresh groundwater in the semi-arid to arid coastal plains is, in its composition, similar to groundwater from wadi aquifers and is also similar in its origin: Quaternary coastal aquifers generally contain saline groundwater which is overlain by fresh water in channel-like systems analogous to the present drainage pattern and to former wadi systems. These groundwaters are mainly found near wadis in the foothill areas, i.e. in the upstream parts of coastal plains. Groundwater salinity is generally higher further downstream and in areas between the wadis.

(f) Hydrochemical composition of groundwater with low salinity

In the semi-arid to arid regions of Western Asia two principal types of groundwater with low salinity occur:

(a) Fossil groundwater in sandstone aquifers and karstic carbonate aquifers;

(b) Groundwater related to present indirect recharge from infiltration of wadi runoff in extended inland wadi systems and in wadis entering the upper reaches of coastal plains.

The hydrochemical composition of the fossil groundwater appears to be determined principally:

(a) Atmospheric inputs with moderate enrichment during recharge;

(b) The mineralogy of the aquifer and its soil cover, which is reflected in:

- Ca-HCO_3 waters with HCO_3 concentrations around 100 mg/l in the sandstone aquifers;
- Ca-Mg-HCO_3 waters in the dolomitic limestone aquifers with HCO_3 concentrations around 200 mg/l.

The fossil groundwater with low salinity extends from the outcrop area of the aquifers, where past recharge has taken place, downstream to regions where the groundwater comes, along the pathways of regional flow, into contact with layers of marine or evaporitic origin or where mixing with brackish or saline water from adjoining aquifers occurs, resulting in increasing concentrations of Cl and SO_4.

Recharge in more recent periods with increasingly arid climate conditions appears restricted to areas affected by wadi runoff and is characterized by higher salinity.

The low salinity groundwater originating from present recharge generally has Cl and SO_4 concentrations between 100 and 240 mg/l, indicating a significant enrichment of atmospheric deposits on the surface before or during the recharge process. The groundwaters are mainly of HCO_3-Cl type with HCO_3 concentrations between 190 and 280 mg/l and varying contents of Ca, Mg and Na. The variation of cation contents may be attributed to the different mineralogical composition of the wadi aquifers and their soil cover and to the varying intensity of the evaporitic processes.

The fresh-water occurrences are generally located near the surface and are limited in their extent to wadis and their immediate surroundings, or even to particular parts of the wadis, and to plains or depressions which receive flood flows from extended wadi systems (9).

2. Brackish groundwater

Brackish water is either plain or difficult. The plain variety is classified as water without any contaminants: this is either well water with high TDS that requires desalting for local water shortages, or steam-electric generator return flow water. Difficult brackish water is classified as industrial and manufacturing and as irrigation return flow water, which typically includes toxicants and contaminants in the waste water. The brackish water is designated as water with total dissolved solids that range from 1,000 ppm to 10,000 ppm.

Table 7 gives brackish qualities and locations horizontally and vertically, together with its current use in the different ESCWA member countries (10).

TABLE 7. BRACKISH WATER AVAILABILITY IN ESCWA MEMBER COUNTRIES

Country	Brackish water location	Aquifers	Depth of aquifer from ground (m)	Present use	Quantity	Quality ppm from	to
Bahrain	Main island of Bahrain	Khober (B)	30-39	Water supply, irrigation	90 million/year (100 per cent country water resources)	8400	2200
People's Democratic Republic of Yemen	Coastal areas along the Arabian Sea (sea water intrusion)	Quaternary alluvium	50-80	Water supply, irrigation	60 MCM/year (Wadi Tiban), (Data on other water basins is not available)		
Egypt	Max pumping station, Parsik pumping station, lower pumping station No.8;	(Return flows)		Irrigation	3.865 billion/year (3.4 per cent of country's total water resources)		
	pumping station No.7;	Nubian sandstone	200-300				
	Bahr el Baqar;					up to 1000	
	Sinai						
Iraq	Mesopotamian plain to Tharthar, Lower Fars, alluvium	Quaternary alluvium	10-50	Water supply, irrigation			
	Main overflow drain (MOD)		-	-	Not available	1400	10000
Lebanon	Coastal areas (sea-water intrusion)	Recent alluvium and carvernous limestone	5-10	Water supply	Not available	1000	3000
Jordan	Jordan Valley	Alluvium	0-100	Irrigation by direct application or blended with fresh water	5 mcm³/year	5000	-
	Azraq	Belqa - B_2	10-50				
	W. Dhuleil	Basalt	10-60				
	North-eastern/ eastern desert	Belqa 2	150-200				
	Wadi Araba	Alluvium	30-70				
	Return flow	-	-				
Kuwait	Soleibeyah	Kuwait		Irrigation		5300	2800
	Shagayah	Khobar		Blended with desalinated sea water	Not available		
	Wafra	Umm er Redhuma	30-100				
	Abdali						
Qatar	Northern province	Rusait	20-80	Direct use for agriculture	30 per cent of Qatar's total available water resources	2000	2500
	Southern Province	Umm er Redhuma		Blended with desalinated water, Desalination on a small scale			
	Abdali						

TABLE 7. *(continued)*

Country	Brackish water location	Aquifers	Depth of aquifer from ground (m)	Present use	Quantity	Quality ppm from	Quality ppm to
Oman	South and east of Batinah coast covering 12,600 hectares	Bahinah alluvium	up to 100	Irrigation (direct use)	1500 m^3 per hectare is extracted annually, consisting of 25 per cent of water used for irrigation	4700	3000
	Capital area	Tertiary limestone	up to 100	Blending with desalinated (MSF) sea water, for domestic use	3,000 m^3/d		
	Dhufar	Limestone	100-200	Irrigation			
West Bank and Gaza Strip	Jordan Valley	Alluvium	up to 100	Irrigation	60 mcm^3		
	Wadi Araba	Alluvium	up to 100	Irrigation			
Saudi Arabia	Al-Qatif	Khobar	130	Irrigation	150 m^3/hour per well	2450	
	Hufuf	Umm er Redhuma	240-350	Irrigation	Not available	2500	10000
	Wadi Al-Rash/Qasim	Saq	170-325	Irrigation	Not available	2000	10000
	Al-Quwayah	Khuff	90-170	Irrigation	Not available	2000	57000
	Rus-south	Wadi Alluvium	40-70	Desalination irrigation	Not available		
Syrian Arab Republic	Mesmeyah	Huran	120-200	Mainly for irrigation			
	Wadi Al-Miah	Limestone	200-250		Not available		
	Khanaseer basin	Chert/limestone	200-250			up to 1000	
	Halab	Marl	300			(deep aquifer)	
United Arab Emirates	Al-Sirrah	Alluvium		Irrigation		1000	3000
	Batinah coast			Desalination			
	West coast			Blending with desalinated sea water	Not available		
Yemen	Tihama	Alluvium (sea water intrusion)		Irrigation	Not available		
	Azraq	Belqa - B_2					
	W. Dhuleil	Basalt					
	North-eastern/ eastern desert	Belqa 2					
	Wadi Araba	Alluvium					
	Return flow	-					

Source: United Nations, Economics and Social Commission for Western Asia, "Desalination of brackish water for production of freshwater for domestic and agricultural water supplies in selected countries of the ESCWA region," E/ESCWA/NR/87/12.

II. INTEGRATED MANAGEMENT OF WATER QUALITY AND QUANTITY

A. NECESSITY OF INTEGRATED MANAGEMENT OF WATER QUALITY AND QUANTITY

Most of the ESCWA region is characterized by a precarious water situation. Population growth and economic development have overwhelmed traditional water management practices, and the region is facing water scarcity and mounting pollution are faced to varying degrees. Issues of efficiency, allocation and water quality must be urgently addressed if the impending problem is to be managed effectively. It is now known that annual per capita average of renewable supplies in the region has fallen by about 80 per cent, from 3,436 cubic metres per capita (in 1966) to 667 cubic metres (projected in 2025) (11). These levels are much below the levels of other major regions of the world. In several ESCWA member countries, renewable fresh water will barely cover basic human needs into the next century. In addition, 35 per cent of renewable supplies are provided by rivers flowing from outside the region, and these are vulnerable to abstraction by upstream riparians. Within the ESCWA region, rivers and aquifers crossing national borders invariably involve complex issues of resource management. Accordingly, in most ESCWA member countries, the cost of water quality and pollution control will rise steeply, and expensive desalinated brackish/sea water besides the treated wastewater will be more heavily counted on to increase the water supply.

To study the current status of water quality in the ESCWA region, the available water, pattern of utilization and rate of population growth should be taken into consideration. Hence, the most relevant problem to be addressed is water shortage and its relevance to water quality.

From different studies on water availability in the ESCWA region, broad categories of per capita availability of water were established and are given in table 8.

TABLE 8. WATER AVAILABILITY IN SELECTED ESCWA MEMBER COUNTRIES

Country	Water available 1,000 mcm/yr	Persons/mcm/yr 1990-2000	Water withdrawal km³/yr	% of available water	Munic and Indus.
Egypt	55.5	948-1183	54.0	97	12
Iraq	100.0	189- 262	42.8	43	8
Jordan	0.9	3508-5005	0.8	89	35
Lebanon	3.8	705- 785	0.8	21	15
Oman	2.0	777-1129	0.4	22	6
Saudi Arabia	2.2	6421-9236	2.3	106	6
Syrian Arab Republic	5.5	4635-6540	3.4	129	7
Yemen	2.5	4635-6540	3.4	129	7

Source: World Bank, "A strategy for managing water in the Middle East and North Africa", Washington, D.C., 1994.

Explanatory notes: Measurements of water scarcity in persons per million cubic metres per year:

(a) 100 to 500 = water management problems;
(b) 500-1000 = water stress with large investments required;
(c) >1000 = water scarcity with significant adjustment required;
(d) TOTAL Renewable Water Resources = Internal Renewable Water Resources plus Inflows from Other Countries less Outflow to other Countries >1000 = Absolute Water Scarcity.

It can be inferred from the above data that most ESCWA member countries are facing water scarcity conditions. In addition, recent studies and surveys predict that the per capita water availability will progressively decline and eventually drop below the minimum needed by the end of this century. This may be attributed to various water factors such as a high rate of population growth, the misuse of some important water resources leading to their depletion and water quality degradation, water wastage and reliance on high water consumption methods in irrigation and in some industries.

In addition, it is now known that a rather heavy water consumer is the agriculture sector, which in so many countries of the region utilizes 80 per cent of the available water. The seriousness of this situation must be appreciated in the light of the fact that most of the irrigation methods used in the ESCWA region lead to water losses estimated at between 50 per cent and 80 per cent. Table 9 indicates the percentages of water use for different purposes.

TABLE 9. PATTERN OF WATER USE ACCORDING TO SOCIO-ECONOMIC SECTORS IN THE ESCWA REGION (1992)*

	% sectoral distribution		
Country	Domestic	Industry	Agriculture
Bahrain	32	3	64
Egypt	7	5	88
Iraq	3	5	92
Jordan	29	6	65
Kuwait	35	4	61
Lebanon	11	4	85
Oman	3	3	94
Qatar	-	-	-
Saudi Arabia	45	8	47
Syrian Arab Republic	7	10	83
United Arab Emirates	38	a/	62
Yemen	5	2	93

Source: All figures are from reference (2) except for Bahrain (12), Kuwait (24) and the United Arab Emirates (13), which refer to older data.

* The global figures are 8:25:67 for 1990.(9).

a/ Included in the figure for domestic.

Another area to be considered is the serious loss which is due to the inefficient use of domestic and urban water and to the improper maintenance and inefficient operation of the storage and distribution systems. However, the changing pattern of development in the ESCWA member countries, with greater emphasis being placed on industry, is bound to affect the relative allocation of water among the various users.

B. Overview of water quality

1. Sources of water quality deterioration

It has been repeatedly observed that one of the most critical issues in the region is the accelerated decline of water quality. Such deterioration has a direct effect on the quantity of water available for specific uses. As the quality of water deteriorates, its scope of uses diminishes, thereby reducing supplies and intensifying shortages. Resources degradation in the region is the result of a number of causes, the most important among which are:

(a) An increase in the discharge of untreated or inadequately treated domestic and industrial water;

(b) Discharge from agro-processing plants and a high level of agrochemicals in drainage water;

(c) Discharge of hazardous and toxic industrial wastes;

(d) Saline agricultural drainage from large-scale irrigation;

(e) Overdraft of ground water resources resulting in saline water intrusion from the sea;

(f) Overpumping of groundwater, causing depletion and eventually water quality deterioration.

2. Sources of water pollution

Population increase, with its concomitant urbanization, has resulted in a dramatic rise in urban dwellers in most countries of the region. This, in most instances, was not accompanied by the necessary increase in domestic and urban wastewater treatment facilities. In fact the old practice of discharging wastewater into surface waters has continued in a number of major cities of the region. This must be contrasted with the growing demand for safe drinking water and sanitation services resulting in an increased amount of wastewater that must be treated. Thus, the limited finances available for the services needed are usually directed towards safe drinking water supplies, resulting in overloading of the sewer system and the inability of the wastewater treatment plants to cope with increased loads. The data given in table 10 clearly show the high level of safe drinking water and sanitation services provided in some countries of the region, whether in urban or rural areas. However, information on wastewater treatment plants and their capacities has been given in previous studies and papers. In Egypt, for example, the water and sewage systems are seriously overstressed, and as some surveys have shown the sewers in many parts of the major cities are extremely overloaded and cannot be efficiently maintained, street flooding of sewage from broken and clogged lines is common. The situation in Iraq is exacerbated by the United Nations sanctions imposed on the country in the aftermath of the Gulf war.

The rise of industry and the rapid industrialization that took place in the region in the last three decades of this century have increased the demand for fresh water, but the poor control exercised on industrial water discharge and the type of technologies used have resulted in serious surface water pollution owing to the discharge of industrial wastewater and toxic substances. Even the well established petroleum industry has not been above such practices.

Another aspect of the deteriorating water quality is that of water-related health problems. These can be either biological, due to pathogen-contaminated waters, or chemical, due to toxic materials. Both urban and rural areas in the region are subject to serious health risks from wastewater. The rather high level of biological contamination of surface water seems to be common among most countries; it is a matter of great concern because it affects the quality of life in the region.

In addition, the authorities responsible for water control have continued to operate along traditional lines, with marginal changes brought about on an ad hoc basis. These authorities concerned themselves mainly with ensuring a minimum level of safety in the water supply, mainly with respect to the absence of pathogenic contaminants. Their role *vis-à-vis* the misuse of water sources was limited to preventing the discharge of raw domestic wastes into the mainstreams. Hardly any control was exercised over the discharge of industrial effluents or of inadequately treated wastewater. The question of the degradation of main water resources, surface or ground waters, owing to agricultural drainage or the contamination arising from toxic agrochemicals, was seldom considered.

TABLE 10. PERCENTAGE OF POPULATION WITH ACCESS TO SAFE DRINKING WATER AND SANITATION IN SELECTED COUNTRIES OF THE ESCWA REGION (1988)

Country	Safe drinking water		Sanitation services	
	Urban	Rural	Urban	Rural
Egypt	96	82	100	34
Iraq	100	72	92	55
Jordan	100	98	100	100
Oman	87	42	100	34
Saudi Arabia	100	74	100	30
Syrian Arab Republic	91	68	72	55
Yemen[a/]	100	48	66	-

Source: United States Agency for International Development, Bureau for the Near East, "Water Resources Action Plan for the Near East," Washington, D.C., 1993.

a/ *Figures are for former Yemen Arab Republic.*

The situation is further complicated by the fact that in many countries of the region responsibilities for water resources are divided among various governmental and public departments with, in some cases, no central authority responsible for all aspects or the water sector. Thus, there seems to be no single body responsible for water quality management. Water quality issues are dealt with in an ad hoc manner by the different ministries. Water authorities as such mainly handle water distribution systems and treatment, such as disinfection of water supplies, if needed. The level of technical competence and the inadequate training have made it difficult for the water authorities to address the problems arising from water resource degradation in most countries of the region.

However, recent interest in environmental issues and especially in the impact of development on the environment, has led to greater attention being paid in most countries of the region to the question of water resource pollution. Consequently, this is expected to lead to the enactment of environmental quality standards, especially quality standards.

So far, the responsible authorities in the region have accepted international standards, and specifically the World Health Organization (WHO) guidelines in most cases. This must be viewed with caution because of the important differences and peculiarities of the region and the ESCWA member countries with respect to most environmental problems, not least among them are the climatic and soil conditions. To this must be added the socio-economic and environmental requirements for sustainable development in the region. All this must emphasize the need for an endogenous water system built upon a clearly stated national and regional water policy. Water quality, in all its aspects, can only be considered rationally within the framework of a system that recognizes the realities of the water situation as part of the socio-economic and geopolitical milieus of the region.

C. INSTITUTIONS AND LEGISLATION DEALING WITH WATER QUALITY

The following is a summary of the country-by-country situation of legislation and institutions related to water quantity and quality. The information presented herein was gathered, as far as possible, from contributions by the countries concerned to ESCWA and other regional and international meetings and organizations as well as from published documents emanating from these organizations.

1. Bahrain

(a) Water resources and quality

(i) The country depends mainly on groundwater augmented by desalinated water;

(ii) Quality of water is "fair" to "poor" and has to be blended with desalinated sea water for the domestic supply.

(b) Water institutions

(i) The Supreme Council for Water Resources incorporates the Water Supply Department and the Roads and Sewerage Department of the Ministry of Works, Electricity and Water, together with the Water Resources Department of the Ministry of Trade and Agriculture.

The mandates of the Council cover water planning, policy formulation, coordination of water activities, groundwater conservation and development;

(ii) The Environmental Protection Committee was established by Amiri Decree No. 7 of 1980 as a coordinating advisory body on environmental issues, including protection of water resources, and water conservation and quality. Besides the Ministry of Health, the Committee includes the Ministry of Electricity and Water and the Ministry of Trade and Agriculture.

(c) Water and related legislation

(i) Law No. 7, 1982 and Law No. 12, 1980 mainly deal with organizational and administrative matters related to groundwater management;

(ii) Public Health Law No. 3, 1975 covers drinking water quality (16, 17, 18, 19, 20, 21, 22).

2. *Egypt*

(a) *Water resources and quality*

(i) The country mainly depends on surface waters, with limited use of groundwater;

(ii) Water quality is "good" for surface water and "fair" for groundwater;

(b) *Water institutions*

(i) Many ministries and agencies are involved in the application and enforcement of water laws and are concerned with issuing standards and with enforcement of those standards. Among them are:

- The National Organization of Potable Water and Sanitary Drainage;
- The Ministry of Public Works and Water Resources;
- The Ministry of Health;
- The Ministry of Agriculture;
- The Ministry of Industry;
- The Ministry of Housing and Public Utilities.

(ii) However, the Egyptian Environmental Affairs Agency, established by Presidential Decree No. 631, 1982, is the coordinating body of the different government sectors dealing with the protection of the environment, including water resources.

(c) *Water and related legislation*

(i) Law No. 93, 1962 deals with liquid effluent discharge, amended by Decree No. 9, 1989. Presidential Decree No. 2703, 1966 established a Supreme Committee chaired by the Minister of Health to investigate all matters related to drinking water, to establish standards and to approve domestic and industrial wastewater disposal projects;

(ii) Law No. 21, 1958 regulates the handling, production, storage and disposal of chemical wastes, and Law No. 53, 1966 concerns the use of pesticides;

(iii) Law No. 38, 1967 on public health, amended by Law No. 31, 1976, regulates the collection and disposal of solid wastes and methods of treatment;

(iv) Law No. 72, 1968 deals with the protection of Egypt's territorial waters and prohibits the dumping of oil at sea;

(v) Law No. 74, 1971 concerns irrigation and drainage, amended by Law No. 12, 1984;

(vi) Law No. 27, 1978 concerns public water sources and standards for water quality of these sources. It gives the Ministry of Health the authority to impose its water quality standards on water used for domestic purposes;

(vii) Law No. 42, 1982 concerns the treatment of industrial effluents before their return to the irrigation or municipal wastewater systems;

(viii) Law No. 48, 1982 concerns the protection of the Nile River and its waterways from pollution and regulates the discharge of wastewater and the use of agrochemicals and herbicides. This law prohibits the discharge of wastes into surface waters unless they meet the criteria to be set by the Ministry of Health and are monitored by the Ministry of Public Works and Irrigation. It also stipulates that drain water may not be mixed with fresh water for agricultural use unless certain criteria are met;

(ix) Decree No. 8, 1983 issued by the Ministry of Irrigation sets specifications for treated wastewater prior to discharge into surface waters, the quality of fresh water into which discharge may be allowed, and the criteria for treated industrial wastewater and for drainage water prior to discharge into fresh water;

(x) Decree No. 55, 1983 issued by Ministry of Manpower sets guidelines for dealing with hazardous materials including radioactive materials and wastes;

(xi) Law No. 40, 1994 concerns the protection of the environment, including water resources (16, 18, 19, 27, 28).

3. *Iraq*

(a) *Water resources and quality*

(i) The country depends mainly on surface waters, with limited use of groundwater, especially in the foothills and desert plains;

(ii) Surface water quality is "good" in the upper reaches of the Tigris, but "fair" for the Euphrates, and for both rivers water quality deteriorates in the southern reaches. The quality of Shatt Al-Arab water is "poor";

(iii) Groundwater quality is variable and is generally mineralized.

(b) *Water institutions*

(i) Several administrative bodies are responsible for water affairs in Baghdad and in the provinces. Among them are:

- Ministry of Irrigation - Water Resources Department;
- Ministry of Planning - Department of Construction, Building and Services;
- Ministry of Health - Department of Environmental Health;
- Ministry of Agriculture - Groundwater Department;
- Baghdad Water Supply and Sewerage Administration;
- State Establishment for Water and Sewerage - responsible for local provincial administrations.

(ii) However, the Higher Council for Protection and Improvement of the Environment, with the Department of Improvement and Protection of Environment attached to the Ministry of Health acting as its technical secretariat, is responsible for setting, among other things, water quality standards, as well as for carrying out audits and assessment of water quality and pollution in the country.

(c) *Water and related legislations*

(i) Law No. 25, 1967 deals with the protection of rivers and public waters;

(ii) Law No. 4, 1972 contains provisions for the use of pesticides;

(iii) Law No. 76, 1986 for the protection and improvement of the environment, established the Higher Council for the Protection and Improvement of the environment;

(iv) Comprehensive legislation on water, water resource protection, and water use has been drafted (16, 17, 18, 24, 26).

4. Jordan

(a) *Water resources and quality*

(i) The country depends on both groundwater and surface waters;

(ii) Surface water quality is generally "fair" to "good", but groundwater quality is "variable".

(b) *Water institutions*

(i) The Ministry of Water and Irrigation is the sole body responsible for the formulation and implementation of water and wastewater development programmes;

(ii) The Water Authority of Jordan and the Jordan Valley Authority are affiliated with the Ministry; the former has responsibility for water supply, sewerage and water resources, while the latter has the responsibility for irrigation and development of the water resources of the Valley, and the central Ministry runs overall planning, financing and legal affairs;

(iii) Several governmental organizations are responsible for protection of water quality. The Department of Environment at the Ministry of Municipalities, Rural Affairs and Environment is undertaking the drafting of regulations for the protection of water resources;

(iv) The laboratories of the Ministry of Water and Irrigation, the Ministry of Health, and the Municipality of Greater Amman undertake routine water analyses to ensure water quality in accordance with adopted standards and specifications. The laboratories of the Royal Scientific Society and of the University of Jordan also take part in such work (16, 17, 18, 19).

5. Kuwait

(a) *Water resources and quality*

(i) The main natural resources and groundwater are of "poor" quality;

(ii) Country water supply depends substantially on desalination of seawater.

(b) *Water institutions*

(i) The Ministry of Electricity and Water is the central authority responsible for water affairs;

(ii) The Department of Environment Protection is the technical secretariat of the Environment Protection Council chaired by the Minister of Health. It handles matters related to environmental pollution, including water resources and water quality;

(iii) The Kuwait Institute for Scientific Research, established in 1981, includes among its activities the development of natural resources, particularly water resources, in cooperation with concerned authorities.

(c) *Water and related legislation*

(i) The Amiri Decree establishing the Ministry of Electricity and Water deals with water projects, including desalination plants, groundwater exploration and utilization, and water supply installations, including blending and drinking water distribution;

(ii) Law No. 12, 1964 on marine pollution control and General Law No. 62, 1980 on the protection of the environment both deal with issues relating to the protection of water resources;

(iii) Decision No. 318, 1978 concerning the management of pesticides and chemical products deals with matters related to pesticide use and control;

(iv) Law No. 94, 1983 concerns land and water utilization for agriculture and fisheries and the establishment of the General Commission for Agriculture and Fisheries (13,16,17,18,19).

6. Lebanon

(a) *Water resources and quality*

(i) The country depends on both surface and ground waters;

(ii) Water quality is generally "good".

(b) *Water institutions*

(i) Besides the Ministry of Electricity and Water Resources, with its reorganized autonomous provincial offices for water affairs, other authorities such as the Drinking Water Supply and Sewerage Authority and the National Authority for the Litani River, function independently. Apart from the latter, their area of responsibility covers the whole country;

(ii) The Agricultural Research Centre handles investigations in the areas of irrigation techniques, water management systems and drainage;

(iii) The Ministry of Environment is still in its infancy. A national environmental management programme is being implemented and is being overseen by an Inter-Agency Working Group on Environment involving the Ministry and other governmental institutions as well as a number of United Nations organizations.

(c) *Water and related legislation*

(i) The law establishing the Ministry of Electricity and Water Resources made the Ministry the sole body responsible for the management of water for the whole country. The mandates given to the Ministry are limited;

(ii) In 1993, the Ministry of Environment was established by law, and its mandates included the responsibility for the protection of water resources from pollution and for environmental management, standards and regulations (6, 16, 17, 18, 30).

7. *Oman*

(a) *Water resources and quality*

(i) The country depends on both ground and surface waters;
(ii) Water quality is "good" in general.

(b) *Water institutions*

(i) The Water Resources Council was established in 1985 as the supreme body for the formulation of a national plan for the development and protection of water resources. It was empowered to decide upon all matters, plans and projects related to water;

(ii) The General Commission for Water Resources was established in 1979 to deal with policy, legislative and regulatory matters concerning water resources, the carrying out of research and studies on the development of new and existing water resources. Furthermore, the Commission is to undertake training and the setting up of a central data bank on water resources in the country;

(iii) The Ministry of Electricity and Water is the body responsible for the domestic water supply;

(iv) The Ministry of Agriculture and Fisheries is in charge of irrigation water and systems;

(v) The Ministry of Regional Municipalities and Environment and the Council for Environment Protection and Pollution Control are the authorities entitled to issue environmental quality standards and regulations for the protection of natural resources inclusive of water resources, coastal waters and marine environment.

(c) *Water and related legislation*

(i) Royal Decree No. 34,1974, issued the Law relating to the control of marine pollution;

(ii) Royal Decree No. 76,1977, issued the Law for the development of water resources;

(iii) Royal Decree No. 63,1979, established the General Commission for Water Resources;

(iv) Royal Decree No. 68,1979, established the Council for Environment Protection and Pollution Control;

(v) Royal Decree No. 53,1981, issued the Law for marine fisheries and the protection of aquatic life;

(vi) Royal Decree No. 10,1982, issued the Law concerning environmental protection and pollution control;

(vii) Royal Decree No. 45,1985, established the Water Resources Council;

(viii) Royal Decree No. 31,1993, merged the Ministry of Environment and the Ministry of Municipalities to form the Ministry of Regional Municipalities and Environment (16, 17, 18, 31, 32).

8. Qatar

(a) Water resources and quality

(i) The country depends mainly on groundwater augmented by desalinated water;
(ii) Groundwater quality is "fair", but in some regions the quality has deteriorated.

(b) Water institutions

(i) The Ministry of Electricity and Water is responsible for the domestic water supply system and water desalination plants;

(ii) The Ministry of Municipal Affairs and Agriculture, with the newly affiliated Environmental Protection Committee, is responsible for groundwater management and irrigation water supply, as well as matters related to the protection of natural resources, inclusive of water resources;

(iii) The Department of Agricultural and Water Research was established in 1982 to undertake research and development activities concerning agricultural development and water resource protection.

(c) Water and related legislation

(i) Law No. 1,1988 concerns groundwater management and the construction of wells, their utilization and control through a licensing system;

(ii) Amiri Decree No. 13,1994, amends Law No. 4,1981 whereupon the Environmental Protection Committee was transferred from the Ministry of Public Health to the Ministry of Municipal Affairs and Agriculture (16, 17, 18, 33).

9. Saudi Arabia

(a) Water resources and quality

(i) The country mainly depends on groundwater resources. Some regions in the country, the western highlands for example, depend also on surface waters. Desalinated seawater makes up for a substantial part of the water needs of the country;

(ii) Groundwater quality is generally "good".

(b) *Water institutions*

(i) The Ministry of Agriculture and Water is in charge of groundwater and surface water resources with respect to their development, conservation and protection. The Ministry is also mandated to prepare the national water plan and to formulate policies and issue the necessary regulations. Among its duties is the management of wastewater treatment systems and the distribution of treated wastewater for irrigation;

(ii) The Ministry of Municipality, Rural Affairs and Water Authorities is in charge of municipal and rural water distribution networks and sewage systems. It is also in charge of wastewater treatment plants;

(iii) The General Organization for Water Desalination is an independent governmental body with sole responsibility for desalination plants and the network for distribution of desalinated water to regional authorities;

(iv) The Coordinated Committee for Environment Protection was established under the chairmanship of the Second Deputy Prime Minister and includes in its membership representatives of ministries involved in environmental protection. Its technical arm is the Administration of Meteorology and Environment Protection, which also handles executive matters such as environmental regulations and programmes, including environmental standards, monitoring of air and water quality and the preparation of national plans;

(v) The King Abdul Aziz City for Science and Technology is concerned with research and development related, among others, to water resources, and water quality issues (16, 17, 18, 19, 23, 24).

10. Syrian Arab Republic

(a) *Water resources and quality*

(i) The country mainly depends on surface water, and in certain regions on groundwater;

(ii) Water quality is generally "good" except for some regions where it could be classified as "fair".

(b) *Water institutions*

(i) The Ministry of Irrigation, with responsibility for water affairs over the whole country, comprises a number of departments handling specific areas alongside six general directorates for the management of the seven major water basins in the country with headquarters located in their respective regions;

(ii) The Water Research Centre was established as part of the Ministry, which also contained a pollution control department;

(iii) The General Company for Water Studies was formed and attached to the Minister of Irrigation. Its responsibilities are to prepare project plans and oversee all water projects in the country;

(iv) The General Company for Irrigation and Drinking Water Supply handles water supply and irrigation projects;

(v) The Ministry of Housing and Urban Development is responsible for the drinking water supply and sewage system;

(vi) The Ministry of State for Environmental Affairs acts as an advisory coordinating body on environmental issues and is responsible for setting up environmental standards and carrying out pollution monitoring programmes, and pollution protection measures, including water resources.

(c) Water and related legislation

(i) Decree No. 144,1925, dealt with public ownership of water resources and licensing;

(ii) Law No. 165,1959 concerns agricultural use of public water sources;

(iii) Law No. 10,1972 concerns pollution of territorial waters;

(iv) Law No. 46,1972 regulates the use of public irrigation networks;

(v) Law No. 16,1982, established the Ministry of Irrigation with mandates covering the whole of water resource management, assessment and planning, as well as training and data collection and dissemination;

(vi) Law No. 3,1984 concerns land reform and water rights (16, 17, 18, 34, 35, 36).

11. United Arab Emirates

(a) Water resources and quality

(i) The country depends mainly on groundwater, which is augmented by desalinated sea water and treated wastewater;

(ii) Groundwater quality is generally "fair".

(b) Water institutions

(i) The General Water Resources Commission is the central federal authority on water;

(ii) The Ministry of Electricity and Water is a federal ministry responsible for water supply systems and desalination plants;

(iii) The Ministry of Agriculture and Fisheries is another federal ministry in charge of the irrigation water supply and groundwater surveys, development and monitoring;

(iv) The General Directorate of the Federal Environment Agency comes under the Ministry of Health and is the technical and executive arm of the Agency.

(c) *Water and related legislation*

(i) Law No. 8,1978, on the conservation of oil resources, contains provisions for the protection of groundwater and territorial waters against pollution resulting from oil production;

(ii) Law No. 21,1981, established the General Water Resources Commission. It deals with water policy, planning and coordination of water activities, as well as control, management and development of water resources. It is also required to organize a data bank on water resources and water uses;

(iii) Law No. 7,1993, provides for the formation of the Federal Environment Agency. It has among its responsibilities the protection of water resources and the creation of environmental standards (16, 17, 18, 37).

12. Yemen

(a) *Water resources and quality*

(i) The country depends mainly on groundwater as the most reliable source, although there is good surface water potential;

(ii) Quality of groundwater varies from "fair" to "good"; in some regions water quality is deteriorating.

(b) *Water institutions*

(i) The Higher Water Council;

(ii) The Ministry of Municipality and Housing;

(iii) The Ministry of Agriculture;

(iv) The General Organization for Water and Sanitary Drainage (the available information does not allow description of the scope and duties of the aforementioned institutions beyond a general statement that they are responsible for water affairs);

(v) The Environmental Protection Council, an executive body that coordinates all environmental issues between the ministries, was to be formed in accordance with the basic law for environmental protection yet to be ratified by Parliament.

(c) *Water and related legislation*

(i) As far as available information indicates, no water legislation has been promulgated after unification in 1990 to deal with water. It is expected that the legislation in effect before unification is still followed pending the enactment of new laws for the whole country;

(ii) Law No. 11,1993 concerns the protection of the marine environment from pollution (16, 17, 18, 38, 39).

III. WATER QUALITY CRITERIA AND GUIDELINES

Naturally, water is free of pollutants, unless a water body is tampered with for reasons ranging from recreation, agriculture and mining to industrial purposes and domestic sewage disposal. Water then loses its pollution-free state and becomes contaminated; the known chemical formula H_2O becomes more complicated. Man-made activities may cause contamination and pollution of rivers, lakes, sea water and groundwater. For example, an oil spill from a tanker may cause contamination of sea water; leaching effects from a solid waste dump (septic tanks) may cause pollution of groundwater; while excessive chemical emissions from an industry can cause pollution of the moisture in the atmosphere, resulting in acid rain which contaminates surface water. Effluents from sewage waste water may stimulate biological and microbiological activities. In addition, waterborne diseases are common problems in most developing countries. It has been estimated that the incidence of waterborne disease on a global basis is 800,000,000 cases of gastro-enteritis, schistosomiasis; filariasis; malaria; and onchocerciasis every year.

As mentioned in chapter II, integrated management of the quantity and quality of water resources is a necessity. This will imply that the acceptable water quality depends on the end-use of that water: water that is suitable for agriculture may not be suitable for certain sophisticated industrial uses, such as those in the pharmaceutical industries. Even for drinking water, the water quality may vary from one country to another. Thus, the quality standards or guidelines set by Governments and authorized agencies in developed countries are significantly different from those that are accepted by similar agencies in developing countries. To set standards or guidelines for water quality, criteria should be established by monitoring the quality of different water sources.

A. WATER QUALITY MONITORING

Water quality monitoring can only be properly understood in relation to the wider issue of water quality assessment. Water quality monitoring is an important component of water quality assessment which refers to the evaluation of the physical, chemical and biological nature of water in relation to natural quality, human effects and intended uses. Water quality assessment includes the use of monitoring to define the current condition of the water, to provide the basis for detecting trends and to provide the information needed to establish water quality standards.

Closely related to water quality monitoring are two other activities, viz., water quality survey and surveillance. It may be useful to differentiate these activities, which come under the umbrella of water quality assessment. Their operational definitions are:(14)

(a) Monitoring: Long-term standardized measurement, observation, evaluation and reporting of the aquatic environment in order to define status and trends;

(b) Survey: A short-term intensive programme to measure, evaluate and report the quality of the aquatic environment for a specific purpose;

(c) Surveillance: Continuous, specific measurement, observation and reporting for the purpose of water quality management and operational activities.

The differentiation of these activities, each one from the others, is very important for the simple fact that what may be taken as water quality monitoring activity in the countries of the ESCWA region are in most cases short-term surveys lacking continuity, which is very important in establishing trends, and therefore in providing factual information that forms the basis for national and regional water quality standards and legislation.

In the light of the available information on water quality monitoring in the region, it could safely be said that there is a direct need for the design and implementation of a water quality assessment programme in which water quality monitoring operations are clearly defined.

B. Water quality legislation

Legislation related to water quality is primarily based upon water quality standards. These standards cannot be formulated in universally applicable terms but must reflect particular situations that pertain to regional and national issues and to the requirements of expanding urbanization and industrialization, as well as other socio-economic and geopolitical factors (40).

To assist national authorities in the formulation of appropriate standards, guidelines have been issued by international and national agencies, such as the "Guidelines for drinking-water quality" prepared by the World Health Organization, and guidelines and directives of the United States Environmental Protection Agency. These guidelines are intended as a basis for the development of national standards that can be used in the promulgation of the necessary legislation to ensure the proper implementation of these standards (15).

Besides the quality standard requirements, legislation may also stipulate the treatment that must be carried out to ensure that the water meets the levels and the specifications laid down in the standards.

There are two approaches, which are not necessarily mutually exclusive, upon which water quality standards may be based and are further used in the laws and regulations to be adopted at the national levels, and also in any possible regional agreements:

(a) Stream standards deal with the source water quality and are based on threshold values of specific pollutants. They are decided upon in the light of the assimilative capacity of the source water, as well as the intended use of the water, and therefore are intimately connected with the type of treatment required in order to meet the criteria laid down in the standards;

(b) Effluent standards deal with the concentration of pollutants that can be discharged, and are based on the maximum concentration of a pollutant as well as on the maximum load discharged into a receiving body of water. The management of these standards involves the equitable allocation of pollutional loads among possibly many municipal and industrial complexes, and limitation on the volume of irrigational water to agricultural land relative to the type of drainage.

In respect to effluent standards, European and American legislation requires a certain level of treatment for industrial wastewater discharges to ensure their compliance with standard criteria. These are usually developed for each industrial category. In most developed countries these criteria are subjected to revision congruent with the level of technological development and state-of-the-art analytical methods for the detection of toxic substances. For example, in the U.S., legislation required that by 1 July 1977 each industry obtain a level of treatment defined as the Best Practicable Control Technology Currently Available (BPCTCA). By 1983, each industry should have achieved a level of treatment defined as Best Available Treatment Economically Achievable (BATEA). Thus, the latter goes beyond BPCTCA, which stipulates the use, if needed, of treatments that have been proven feasible. Furthermore, the U.S. Environmental Protection Agency has developed pretreatment guidelines for those industrial plants which discharge into municipal sewer systems.

The above discourse helps to emphasize the point that each country and region has to develop its own water quality criteria and standards and to formulate its own legislative and control systems to serve best its national and regional interests. Thus, the stage of advancement in developed countries and regions may call for the most astringent rules and regulations; on the other hand, many developing countries may find that they have to accept a compromise in order to cope with their developmental requirements.

The ESCWA member countries, in formulating their national legislation for water quality standards and controls, must arrive at their own judgement of safety and what can be tolerated as acceptable level of risk in every particular circumstance (15).

C. WATER QUALITY CONTROL

Water quality control relates to the establishment of water quality criteria, standards and the related legislation used as the main administrative means to manage water quality in order to achieve user requirements.

The natural quality of water has been altered by the impact of various human activities and water uses. Thus, water quality is affected by the uses shown below:

(a) Municipal: sewage discharge, stormwater run-off;
(b) Agricultural: manure disposal, use of agrochemicals, drainage water discharge;
(c) Industrial: wastewater effluents, cooling water discharge, acid mine drainage.

On the other hand, water uses are also affected by the quality of water. Thus, many uses put severe requirements on the type of water needed. This is illustrated in the following uses of water that have special quality requirements:

(a) Municipal water for drinking, domestic and public uses;
(b) Agricultural uses for farm supplies, livestock watering and irrigation;
(c) Industrial uses for cooling boiler feeding, processing and mining;
(d) Recreational uses such as water-contact sports and fishing;
(e) Aquatic life needs for wildlife, fishing, water habitat and aquaculture.

In general, water quality may be considered in terms of the following:

(a) The quality of the aquatic environment, which is defined by a set of concentrations, speciations and physical partitions of inorganic and organic substances; and the composition and state of aquatic biota found in the water body. These show both spatial and temporal variations due to internal and external factors;

(b) Pollution of the aquatic environment, which means the direct or indirect introduction by man of substances or energy which result in deleterious effects that limit or prevent the intended use of water and/or its suitability for various activities and life forms.

D. WATER QUALITY VARIABLES

The requirement of a certain quality of water for any particular use is described through a set of variables relating to the hydrological, physico-chemical and biological properties of the water. These quality variables have evolved over time and are constantly refined in line with expanding uses, greater environmental awareness and development in analytical methods for the detection of smaller concentrations of pollutants, as well as capabilities to determine their toxic effects.

Based upon practical considerations of water use requirements, water quality variables are grouped into broad categories. These are:

(a) Hydrological variables such as flow rate, discharge, water level and suspended matter transport;

(b) Nutrients which are key factors for aquatic life and various uses, such as nitrogen compounds (ammonia and nitrate) and phosphorus compounds;

(c) Organic matter with adverse effects on humans and aquatic life as measured by total organic carbon, chemical and biochemical oxygen demands, and humic and folic acids;

(d) Salinity and specific major ions which play an important role in determining the suitability of a water resource for most uses. Examples are sodium, potassium, calcium, magnesium, carbonates, bicarbonates, chlorides, sulphates, sulphide, silica, fluoride, boron and cyanide;

(e) Inorganic micro-pollutants, which are trace metals with adverse effect on humans and aquatic life such as aluminum, cadmium, copper, iron, lead, arsenic and mercury.

E. PREVAILING WATER QUALITY CONDITION IN THE ESCWA REGION

As mentioned in chapter I, the term surface water is meant to indicate waters in the rivers, wadi streams and lakes but not including estuarine, coastal or sea water. The quality of such surface water is affected by pollutants from various sources such as domestic waste discharges and industrial waste. One often-cited incident of surface water pollution by industrial wastes is the Orontes River in the Syrian Arab Republic. River waters (Nile, Euphrates, Tigris, Jordan, Litani, Orontes) constitute a significant percentage of fresh surface water in many ESCWA member countries. These river waters serve multiple purposes such as raw water sources for domestic water, irrigation, industry, navigation, power generation and recreation, and as an outlet or carrier of discharges from sewage treatment plants, industries, and the like. It has also been noticed that water quality is also affected by such factors as geology, vegetation, land use, agricultural practices and effluent discharges. River water pollution is common in many ESCWA member countries, pollution problems are repeatedly reported downstream of the Nile, Tigris, Euphrates, Litani, Jordan and Orontes rivers.

In the semi-arid to arid regions of the Syrian steppe and the Arabian Peninsula, there are two principal types of groundwater with low salinity: (a) fossil groundwater in sandstone aquifers and karstic carbonate aquifers; and (b) groundwater related to present indirect recharge from infiltration of wadi runoff. The fossil groundwater contains moderately enriched atmospheric inputs; in presently recharged wadi and coastal aquifers, contents of major constituents, in particular Cl and SO_4 concentrations, are generally more enriched through evaporation before and during the recharge process. The fresh groundwater resources, extending over very limited areas within a vast region containing brackish or saline groundwater, provide valuable sources for water supply and irrigation. Their exploitation should therefore be based on careful extraction management.

F. Drinking water supply guidelines in the ESCWA region

The World Health Organization (WHO), as well as other organizations, is taking an active role in developing guidelines to describe water quality to satisfy economic and consumer health considerations. These guidelines stimulate the importance of analytical monitoring of drinking water quality to avoid ingestion of pollutants such as chemical contamination and bacteria. In 1984 WHO introduced Drinking Water Quality Guidelines (three volumes) superseding both the European Standards and International Standards for Drinking Water which had been in existence for over a decade. The main reason for replacing the previous standards for drinking water quality was the desirability of adopting a risk-benefit approach to the national standards criteria, standards and regulations. Adoption of excessively stringent drinking water standards could limit the availability of water supplies that meet those standards. Hence the WHO Guidelines for drinking water quality were set instead of WHO standards for use by countries as a basis for the development of their own national standards, which, if properly implemented, would ensure the safety of the drinking water supply (15).

It has been emphasized on many occasions that the WHO Guidelines (annex I) are not standards in themselves but recommended levels for water constituents and acceptable contaminations. Therefore, many ESCWA member countries have set their guidelines in line with the WHO Guidelines for drinking water quality. These levels stimulated the continuous need and importance of analytical monitoring of drinking water quality to avoid ingestion of pollutants such as chemicals and bacteria. This prompts the necessity for water quality follow-up in the laboratories.

However, water quality is the primary factor in determining the suitability of water for any particular use or number of uses. Over time, water requirements have emerged for the various socio-economic activities. For some, higher quality water is needed, such as for drinking, personal hygiene or specialized industrial processes; for others, such as for irrigation and industrial cooling, the least is needed in terms of water quality. Although drinking water and specialized industrial processes impose the most stringent demands on water quality, their quantitative needs are relatively moderate. Table 11 provides a comparison of the different requirements for water quality according to various uses.

Table 11. Water quality requirements for different uses

Use	Quality criteria
Water supply, recreation	Coliform bacteria, color, turbidity, pH, dissolved oxygen, toxic materials, taste- and odor-producing chemicals, temperature
Bathing, fish life, recreation	Coliform bacteria, pH, dissolved oxygen, toxic materials, color and turbidity (at high levels), temperature
Industrial, agricultural, navigation, fish life	Dissolved oxygen, pH, floating and settleable solids, temperature
Navigation, cooling, water	Nuisance-free conditions, floating material, pH

Source: D. Chapmen, "Water quality asessment", a guide to the use of biota, sediments and waters in environmental monitoring, published on behalf of UNESCO/WHO/UNEP. Chapman and Hall, London, 1992.

Water intended for human consumption and food production should not only be safe but also attractive in appearance, odour and taste.

The quality of water intended for drinking should meet required standards/guidelines or criteria at the raw water sources level, at the pre- and post-treatment level, at various points in the distribution system and ultimately at the point of consumption. Drinking water quality is expressed in terms of its physical, chemical, microbiological and radiological characteristics. Physical characteristics are expressed in terms of colour, odour, taste, turbidity, temperature, electrical conductivity, pH, total dissolved solids and suspended solids.

The chemical parameters are either organic or inorganic in nature. Some 496 organic chemicals have been reported or are suspected to be present in freshwater. Of these, only 66 have been identified. Municipal, domestic, agricultural and industrial sources are mostly responsible for the largest number and variety of organic chemicals in water. Around 266 inorganic chemical parameters have been reported to be present in freshwater, but only 87 have been identified.

In the ESCWA region, drinking water quality has received great attention in recent times, not only because of the rise in demand but also because of the degradation of the usual sources of water for public supply. Every effort should be directed towards achieving a drinking-water quality that is as high as practicable. Protection of water supplies from contamination is the first line of defence. Source protection is almost invariably the best method of ensuring safe drinking water and is preferable to treating a contaminated water supply to render it suitable for consumption. Annex II contains examples of standards and guidelines for drinking water quality followed in selected ESCWA member countries.

Many chemical substances emitted into the surroundings as a result of man-made activities pose a threat to the utilization of water for human consumption, irrigation and other purposes. This applies in particular to substances that are toxic even at relatively low concentrations. Water quality survey monitoring and surveillance in different ESCWA member countries have been increasingly used to promote national water quality guidelines or standards to prevent, control and reduce the emission of hazardous substances and the excessive release of conventional water pollutants into different water regimes, taking into consideration the water quality characteristics (chapter I) and related environmental and water problems.

The following is a summary, on a country level, of the main prevailing water quality issues and standards, guidelines or criteria which are used in the ESCWA region:

1. Bahrain

(a) WHO guidelines for drinking water quality are used;

(b) The Environment Protection Committee issued proposed guidelines for effluent discharge;

(c) United States Environmental Protection Agency standards and Saudi Arabian Department of Meteorology and Environmental Protection guidelines are also followed;

(d) As yet, there is no comprehensive national water plan for water quality monitoring and assessment;

(e) Serious concern has been raised about the continued deterioration of groundwater quality as well as its possible depletion. A major awareness campaign for water conservation was initiated in 1994;

(f) Non-conventional water resources, e.g., treated wastewater, are to be used on wider scale in both agriculture and industry (16, 17, 18, 19, 20, 21, 22).

2. Egypt

(a) WHO guidelines for drinking water quality are followed;

(b) The Supreme Committee, formed by Presidential Decree No. 2703,1966, referred to in (2.a) above, issued standards and specifications for the maximum level of contaminants permissible in potable water;

(c) The Ministry of Irrigation, pursuant to the Law No. 48,1982 on the protection of the Nile, issued specifications for:

- Treated wastewater prior to discharge into surface waters;
- Quality of fresh water into which discharge might be allowed (source standards);
- Criteria for treated industrial wastewater (effluent standards);
- Criteria for drainage water if returned to fresh surface waters.

(d) In 1975 a water policy was formulated on the basis of the available water resources. This has since been developed into several programmes concerning water use and water conservation, foremost among which are the water management programmes currently under implementation;

(e) The Egyptian Environmental Affairs Agency issued in 1992 the Environment Plan of Action. Among the activities of the Agency that pertain to water quality are the environmental impact assessments relating to the protection of surface and groundwater resources;

(f) Overloading of the sewage system in Cairo and other major cities of the Delta is seriously affecting the drinking water supply network;

(g) The inability of the industrial sector to meet the requirements of Law No. 42 because of the costly treatment process stipulated by the law is resulting in the discharge of inadequately treated industrial effluents into surface waters or the municipal sewerage;

(h) Contaminated drainage water in the Nile Delta, due to the increased use of agrochemicals and pesticides, is affecting the quality of both surface water and the shallow aquifers. Significant quantities of used pesticides pass from agriculture drainage into the Nile (16, 18, 19, 27, 28).

3. Iraq

(a) National standards for water quality are being set. WHO guidelines for drinking water quality are followed;

(b) The responsible administrations of the ministries of Health, Irrigation and Industry and the provincial authorities set specifications for effluent discharge;

(c) The reduced water flow of the Euphrates, and the similar situation threatening the Tigris, owing to extensive construction in Turkey, and to some extent in the Syrian Arab Republic, of massive dams and other water control projects, have resulted in increased water salinity in the upper reaches of the Euphrates and, to a lesser extent, in the Tigris;

(d) The United Nations sanctions imposed upon Iraq in the wake of the Gulf war caused severe dilapidation of the water supply and sewerage systems all over the country, and especially in the major towns, and demonstratively in the capital Baghdad, where the lack of spare parts and proper maintenance services for an otherwise a well-run network has caused serious problems with drinking water contamination, and the breakdown of the sewerage pumping system;

(e) The water quality of Shatt Al-Arab, as well as that of the lower reaches of both the Euphrates and the Tigris, has seriously deteriorated owing to several deleterious factors, among which for Shatt Al-Arab, is sea-water intrusion and the discharge of agricultural drainage and untreated or inadequately treated municipal and industrial wastewater;

(f) The construction of the major drainage canal in the central and southern mesopotamia is expected to affect the quality of the surface waters of the marshes in southern Iraq (16, 17, 18, 24, 26).

4. Jordan

(a) The guidelines for drinking water quality issued by WHO are followed;

(b) The Ministry of Water and Irrigation is responsible for routine monitoring of the quality of water resources. In accordance with the Law No. 18, the Water Authority of Jordan is empowered to issue approved water quality standards for different uses and to protect water resources from pollution;

(c) The Jordan Valley Authority has put into force regulations for the protection of the Jordan Valley and controls of the discharge of polluting materials into the water resources of the Valley;

(d) Pending the promulgation of the Environment Protection Law, several draft regulations on protection of water resources and other environmental matters have been prepared;

(e) The priority given to water in Jordan has made water an issue of prime national importance. Jordan has undertaken country-wide surveys and monitoring schemes for potential water resources;

(f) Short-, medium- and long-term water supply strategies have been prepared. The strategies are based on the future development of conventional and non-conventional water resources within Jordan. It is expected that Jordan's projected demands for municipal water can only be met by Draconian measures and substantial investments in the water sector;

(g) One major issue which the country faces is the deteriorating water quality owing to various factors such as brackish and saline water intrusion, uncontrolled discharge, irrigation water drainage and pollution from pesticides and toxic materials;

(h) A problem of country-wide importance which has received serious attention is the increasing salinity of both surface waters and groundwater. This has been attributed to overdraft conditions, low recharge and return flow from irrigated areas, especially to the Jordan river;

(i) Jordan is among the few countries of the region that have undertaken the organization of a national data bank for water resources, including water quality record files (16, 17, 18, 19).

5. Kuwait

(a) WHO guidelines for drinking water quality are followed;

(b) Environment quality forms an important part of the third five-year work plan covering the period 1991-1996 issued by the Environment Protection Council. The plan includes water quality and marine environment control and management;

(c) The aftermath of the Gulf war created great concern for the environment and for the control of pollution of air, soil and water, as well as for the marine environment, including coastal waters. Among the issues of interest that affect water quality are the oil pools that resulted from the gushing oil wells and which produced serious pollution of the topsoil, as well as the large quantity of salt water used for fire lighting. The long-term effects of these factors and the discharge of millions of barrels of crude oil have to be carefully monitored. This should include air and water quality monitoring, especially of groundwater and coastal waters;

(d) The limited reserves of fresh groundwater suffer from many factors affecting its quality, among which are the low rate of recharge, intrusion of brackish and sea waters, and transboundary underflow;

(e) Secondary treated effluents are widely used for irrigation. However, more efforts are to be directed towards improving the technology for wastewater treatment and reuse, and for the development of technologies aimed at the rational utilization of sea water (13, 16, 17, 18, 19);

6. *Lebanon*

(a) The guidelines for drinking water quality issued by WHO are followed;

(b) The National Plan for Waste Management, which was formulated in 1982 with WHO assistance, dealt among other things with water reuse and recycling and effluent treatment and their safe discharge into water sources;

(c) It is to be expected that the proposed national environmental management programme would deal with water and other environmental quality standards;

(d) The civil strife that lasted for almost two decades left the country's water systems in conditions of serious neglect. Among the issues of greatest urgency are the restoration of the potable water distribution system, sewerage and treatment plants;

(e) Pollution of water resources owing to accumulation of solid waste and contamination with pesticides are common features;

(f) A problem of paramount importance is the reported chemical contamination of ground and surface water streams attributed to the burial of toxic wastes transported to the country from abroad. Parliamentary and governmental investigations have revealed that toxic waste sites are widespread in the country;

(g) In view of the problem of waterstream pollution by buried toxic wastes, it is interesting to note that in 1970, UNDP conducted a nine year country-wide groundwater study. This would have to be updated in order to take into account all the damage caused to surface- and groundwater quality in Lebanon (6, 16, 17, 18, 30).

7. *Oman*

(a) WHO guidelines for drinking water quality are followed;

(b) The newly drafted Environment Law (1994) stipulates the formulation of national standards commensurate with national priorities for the protection of natural resources;

(c) Some of the important factors affecting water quality in the country are saline water intrusion, insufficient recharge of groundwater and serious coastal water oil pollution;

(d) The problem of sea-water intrusion into the shallow aquifers of the northern coastal areas is further complicated by the heavy pollution of these areas owing to oil sludge and discharge of ballast water by oil-tankers as they enter the Gulf. Oman has put into action contingency plans for the protection of its coastal waters (16, 17, 18, 31, 32).

8. Qatar

(a) WHO guidelines for drinking water quality are followed;

(b) Work is under way to establish a national data bank for water resources by collecting meteorological and hydrological information gathered through the hydrological network established in 1971 as part of the Hydro-Agriculture Survey Programme in cooperation with FAO and its follow-up programme on Integrated Water and Land Use. These activities resulted in the establishment of a large number of monitoring stations;

(c) Sea-water intrusion along the coastal lines and upward leakage from saline water coupled with a very low rate of recharge and overpumping have resulted in the overall deterioration of the natural environment of the groundwater of Qatar as gauged by increased water salinity;

(d) Efforts have been directed towards improved irrigation systems, with the cooperation of FAO, the aim being to increase water efficiency; a water savings of more than 50 per cent was achieved, with crop yield up by more than 20 per cent. Special attention was given in these investigations to the quality of water and the most economical use of fresh water (16, 17, 18, 33).

9. Saudi Arabia

(a) WHO guidelines for drinking water quality are followed;

(b) The Administration of Meteorology and Environment Protection has issued a number of water quality standards, including those related to treated wastewater used for irrigation and industrial effluents. The use and management of pesticides are the subject of a ministerial order issued in 1396 H (1976);

(c) Water demand and supply issues dominate the national planning policy;

(d) Overpumping of aquifers, insufficient recharge and sea-water and brackish water intrusion are among the issues affecting water quality in the country;

(e) Widespread use of tertiary treated wastewater for irrigation necessitates the development of advanced treatment technologies to ensure the required standards (16, 17, 18, 19, 23, 24).

10. Syrian Arab Republic

(a) While WHO guidelines for drinking water quality are followed. The Ministry of Irrigation is in charge of setting up national standards and specifications for water quality, including standards for wastewater, irrigation and drainage water and industrial effluents;

(b) The Ministry of State for Environmental Affairs has completed a draft law on environmental affairs, which, when approved, will give the Ministry executive powers to deal with pollution control and environmental safety;

(c) Although the water supply in the country is generally good, there are regions with a serious water situation, such as the Damascus area, where water demands for domestic and industrial uses are far exceeding local supplies;

(d) Water quality of some sources, especially rivers, is suffering from pollution problems arising from the disposal of industrial and other wastewaters. Currently, a study is being completed on the assessment of the water quality of the Orontes River;

(e) A major plan to assess and control the effect of pollution of water sources in the country is under way;

(f) The decrease in the flow of the Euphrates River, owing to the construction of the huge Ataturk dam in Turkey and the networks of dams and canals, is causing serious concern because of its effect on the quantity and quality of water in the river basin through the Syrian Arab Republic and Iraq and consequently on agricultural output of both countries (16, 17, 18, 34, 35, 36).

11. United Arab Emirates

(a) WHO guidelines for drinking water quality are followed;

(b) Among the duties of the Federal Environment Agency are the setting up of standards and pollution limits for water, as well as pollution monitoring and auditing. In 1994, six regulations dealing with, among other things, hazardous waste, marine environment and air and water sources were drafted;

(c) The protection of groundwater resources from possible pollution and recharge schemes are some of the issues being given special attention;

(d) Alluvial aquifers are especially susceptible to water quality deterioration because of overdraft conditions and salination;

(e) Deterioration of coastal waters by marine pollution from oil spills is a problem of major concern because of its direct effect, among others, on the desalination plants (16, 17, 18, 37).

12. Yemen

(a) WHO guidelines for drinking water quality are followed;

(b) Draft standards for drinking water are still pending ratification;

(c) Pollution of groundwater owing to seepage of untreated domestic wastewater is of special concern, especially in major cities such as Sana'a where several water wells became heavily contaminated with pathogens and had to be abandoned;

(d) Most alluvion aquifers suffer from a decline in water level and salt-water intrusion, especially in coastal areas;

(e) Discharge of raw sewage into the inner harbour and along the sea shores in the Aden area is adversely affecting coastal water quality and raises the danger of serious aquifer contamination by sea-water encroachment (16, 17, 18, 38, 39).

G. WATER QUALITY GUIDELINES FOR IRRIGATION

The water used for agriculture must be of a certain quality and adequacy for irrigation. Using lower quality water requires adapting careful planning to ensure that the available water is put to the most appropriate use. Such planning involves taking into consideration soil and crops in selecting alternatives to cope with potential water quality-related problems that might reduce production under prevailing water quality use.

In chapter I, the characteristics of available water resources in terms of quantity and quality were indicated. These characteristics usually influence its suitability for specific uses. In irrigation water, emphasis is mainly placed on chemical and physical characteristics and rarely are other factors considered important. In this regard, river water loaded with sediment is very useful in irrigation but unacceptable for municipal use without proper treatment.

Of the total amount of water used in the ESCWA region, 70 per cent to 80 per cent is used for agriculture. The so-called green revolution of the 1970s in developing countries, including ESCWA member countries, brought several million hectares of land under cultivation by irrigation. Irrigated agriculture plays an important role in producing food in the region. Water used for irrigation often contains some salts which sometimes may be necessary for the growth of the crop. Often low-saline water in irrigation systems may cause soil permeability problems. Therefore, a particular source of water is good for irrigating a particular type of crop in specific soil is determined by the amounts and types of salts present in the water.

1. Food and Agriculture Organization (FAO) guidelines

Generally, the use of poor quality water for irrigation results in salinity, permeability, toxicity and other effects. There have been a number of different water quality guidelines related to irrigated agriculture. Each was useful in certain aspects, but none has been entirely satisfactory because of the wide variability in the field conditions. The Food and Agriculture Organization (FAO) developed guidelines for interpretation of water quality which relied heavily on previous ones but were modified to give more practical procedures for evaluating and managing water quality-related problems of irrigated agriculture (41). The FAO guidelines for evaluation of water quality for irrigation are indicated in annex III.

As previously mentioned, irrigation is one of the main agricultural consumers of water in the ESCWA region. Poor quality water may affect irrigated crops by causing accumulation of salts in the root zone, by causing loss of permeability of the soil owing to excess sodium or calcium leaching or by containing pathogens or contaminants which are directly toxic to plants. When the presence of pesticides or pathogenic organisms in irrigation water does not affect plant growth and in turn affects the acceptability of the agricultural product, FAO guidelines, adapted in the ESCWA member countries, take into account such characteristics as crop tolerance to salinity, sodium concentration and phytotoxic elements. Sodium in irrigation water (Jordan and the Syrian Arab Republic) can adversely affect soil structure and reduce the rate at which water moves into the soil. However, water quality guidelines in the ESCWA region, may be considerably adjusted (Egypt, Iraq and the Syrian Arab Republic) owing to different annual application rates of irrigation water.

2. *Irrigation water quality and wastewater reuse*

The reuse of wastewater in the production of agricultural crops mainly poses a risk to consumers. It is well known that wastewater is reused extensively in most ESCWA member countries for irrigation. Since wastewater contains impurities, attention must be given to the possible long-term effects on soil and plant from salinity, sodicity, nutrients and trace elements that may be present naturally or are added during treatments.

The disposal of highly saline drainage water into rivers may need to be managed carefully to meet certain minimum requirements of water quality in downstream areas (effect of GAP project in Turkey to water quality of the Euphrates in the Syrian Arab Republic and Iraq). Water and salinity (Syrian Arab Republic, Saudi Arabia, Yemen and Iraq) are hazards threatening agriculture, the need for drainage is often quoted as the solution, for the drainage would affect the quality of the source (surface water and shallow aquifers).

The FAO guidelines and crop salinity tolerance values presented in annex III are markers to estimate soil and crop responses to the use of wastewater.

The effect of wastewater reuse on the public health can only be assessed by an epidemiological study to determine whether or not it results in diseases.

IV. WATER REMEDIATION AND PREVENTION OF WATER POLLUTION: AN OVERVIEW

A. REMEDIATION TO PRODUCE ADDITIONAL WATER

It is generally accepted that preventive measures in the long run are to be preferred to the treatment of already damaged aquatic systems. However, in a situation in which polluted water sources are already an everyday reality, there is no escape from considering the need for treatment processes to remedy as far as possible the impaired sources and to obtain a level of acceptance of the treated water for its intended uses, or for alternative uses for which such water can best be suited and/or develop new techniques such as desalination to provide additional water resources so as to prevent damage of existing water resources such as excessive pumping of groundwater. Water uses lead to water degradation, and the so-called wastewater finds its way into the aquatic cycle and results in the pollution of both surface and groundwaters.

As mentioned in chapter III, water conservation measures, and the imposition of regulatory measures and water quality criteria, standards, or guidelines, with their strict application, can be powerful tools in limiting the deterioration of water sources and the degradation of water quality. Such actions could be very effective in controlling domestic, municipal and industrial wastewater; but control over drainage water and wastewater from agriculture is a more difficult problem. Agricultural runoff is a major contributor to the pollution of natural water sources: rivers, lakes and aquifers.

Examples of deterioration of natural water sources through wastewater disposal and drainage into the water streams in the ESCWA region abound. Thus, explosive urbanization has led to the overloading of the water distribution and sewer systems in many of the large cities in the region, and untreated or partially treated wastewater finds its way to the natural water streams in ever-increasing proportions. Industrial effluents are regularly discharged into rivers and lakes owing to the absence of effective control measures or to the inadequate regulations. Leakage problems and solid wastes dumps or landfills eventually cause serious pollution to ground- and surface waters through runoff and drainage. Uncontrolled use of agrochemicals and inefficient irrigation methods lead to serious pollution problems for natural water resources. Therefore, for the countries of the region, wastewater and runoff water control should be considered an issue of the highest priority.

In this chapter, an overview is presented of wastewater treatment, and remediation processes, and of possible water pollution preventive measures, desalination of sea and brackish water as additional water sources so as to alleviate the use of other water resources, artificial recharge techniques to improve coastal groundwater aquifers, and controlling the sea-water intrusion.

B. WATER REMEDIATION AND WASTEWATER TREATMENT

Wastewater treatment processes are those used in order to upgrade damaged water to the accepted level to allow for its discharge into running streams or possibly for reuse. Water remediation consists of processes applied to treated wastewater in order to bring it to the quality levels that are acceptable for human use. One can therefore say that water remediation starts where wastewater treatment ends. Water remediation may also be considered to be the finishing step in wastewater treatment processes, the so-called tertiary treatment. In some cases water remediation may be effective in upgrading substandard natural waters.

The application of many wastewater treatment processes is related to both the characteristics of the wastewater and the degree of treatment required to meet effluent standards. For any given wastewater treatment, several treatment combinations can produce the desired effluent; therefore, cost and availability will usually be the decisive factors. ESCWA technical publications provide such information.

Wastewater treatment processes usually involve pretreatment or primary treatment processes, which are required in order to prepare the wastewater for the biological treatment processes carried out in the secondary treatment stage. When the removal of pollutants by the biological treatment processes does not produce the quality standard required, then a tertiary treatment has to be carried out.

The tertiary treatment stage involves physical chemical processes required for the removal of such pollutants as suspended solids, biochemical oxygen demand, chemical oxygen demand, organics and micropollutants, nutrients such as nitrogen and phosphorus, heavy metals and inorganic salts. These pollutants are usually removed by conventional processes including carbon adsorption, vaporization, membrane filtration, ion exchange, reverse osmosis, electrodialysis, chemical and biological coprecipitation and nitrification-dentrification. These so-called advanced water treatment processes, together with more recently developed advanced oxidation processes, are of interest not only for wastewater treatment but also for substandard natural water suffering from the presence of the aforementioned pollutants.

The advanced water treatment processes, which are also called water remediation processes, are outlined in table 12. The recently developed advanced oxidation technologies (AOTs) include UV/hydrogen peroxide/ozone oxidation; catalyticoxidation; supercritical water oxidation; electron beam and gamma irradiation; photocatalytic oxidation; electrohydraulic cavitation and sonolysis; and non-thermal plasma.

Some of these technologies have been developed industrially to compete with the more conventional processes in the removal of organic pollutants.

The decision as to which of the available processes or combination of processes is to be selected has to be made according to the characteristics of the water to be treated, the intended use and the cost factor.

To do this, one should evaluate each competing technology in terms of several performance criteria which include specific compound or pollutant removal; total organic carbon removal; associated biotoxicity and biodegradability changes; by-product formation; and the formation of secondary wastes.

Additionally, several measures of merit should be evaluated for each technology for a specific water stream. These should include energy expended per unit of organic matter/pollutant removed; operating and capital costs; personnel requirements; and safety and maintenance.

To place water remediation or advanced wastewater treatment in perspective, table 13 shows the level of pollutants present at the end of the secondary treatment stage that can be treated to produce an effluent of superior quality suitable for several uses.

The ESCWA secretariat has carried out a study on waste water reuse and its applications in Western Asia (E/ESCWA/NR/84/Rev.1). The objectives of that study were to: assess the augmentation of current water supplies through utilization of treated wastewaters from municipal, agriculture and industrial sources; outline the minimum acceptable standards and the required treatment to reach those standards for agriculture and industrial application of the treated effluents; and indicate the required precautions and safeguards against misuse and environmental hazards. In addition, water reuse by renovating and recycling waste water from municipal, agricultural and industrial effluent has gained support in many other regions of the world. Treated waste water can be used for irrigation, for some municipality needs, groundwater recharge, various industrial uses and recreational purposes.

TABLE 12. TERTIARY AND ADVANCED WATER TREATMENT AND REMEDIATION PROCESSES FOR THE REMOVAL OF SPECIFIC POLLUTANTS

Process	Pollutants removed
Filtration-sand, diatomite, mixed media	Suspended solids, phosphate in suspended form, BOD, COD
Filtration with coagulation - mixed media	suspended solids, phosphate, colloidal solids, colour, turbidity, BOD, COD
Coagulation	Phosphate, colour, turbidity, some BOD & COD
Air stripping	Ammonia
Nitrification - dentrification	Nitrogen, BOD
Carbon adsorption	COD, total organic carbon, residual suspended solids, colour
Ion-exchange	Phosphate, nitrogen, total dissolved solids
Reverse osmosis	Organics and inorganics
Electrodialysis	Inorganic salts
Advance oxidation technologies (AOT)	Organics, chlorinated compounds

Source: "Advanced Oxidation Technology for Water and Air Remediation," Abstracts of the First Conference, June, 1994, London, Ontario.

Although wastewater reuse has been practiced in Western Asia for some time, its use has been limited, and large-scale projects are of fairly recent origin. In Qatar, nearly 60 per cent of the budget of the Water Sewerage Department for 1985-1986 was devoted to new projects, including the Doha South and Doha West treatment plants. The Department's budget was US$ 75 million, of which US$ 44.5 million was spent on sewerage projects.

Egypt is expected to recycle 4,200 million cubic metres of water per year within five years and 5,400 mcm/yr by the year 2000. Currently, reused effluent production is around 2,500 mcm/yr.

The cost of treating sewage in Kuwait is only one sixth of that incurred in desalinating sea-water, the country's major water source. Over 7 billion cubic metres of effluent each year is produced at the Ardiyah treatment plant. By the year 2010 the plant is expected to produce 12.5 bcm/yr, which will make it the largest sewage recycling scheme in the Middle East.

The Homs and Hama sewage treatment project in the Syrian Arab Republic has been put out to tender. The estimated cost of the scheme is US$ 150 million and will entail building two treatment units on the Orontes river. It is being financed partially by the World Bank and by the Kuwait-based Arab Fund for Economic and Social Development.

TABLE 13. CHARACTERISTICS OF EFFLUENTS THAT HAVE BEEN SUCCESSFULLY TREATED BY ADVANCED WATER TREATMENT AND REMEDIATION PROCESSES

Constituent	Content[a/]
Suspended solids	20 mg/l
Volatile suspended solids	10 mg/l
BOD	10 mg/l
COD	150 mg/l
Phosphate, as P	10 mg/l
Nitrogen, as N	50 mg/l
Chlorides	1700 mg/l
pH	6-8

a/ The figures refer to real-situation cases of sewage, refinery and petrochemical effluents after undergoing secondary treatment (18).

The Water Authority of Jordan (WAJ) is also exploring the agricultural potential of treated waste water. *The Khirbet al-Samra waste water treatment plant is being built at a cost of* US$ 47.6 million. It will be used as a model for additional plants in Jordan as well as a research centre for the use of treated water in agriculture. A similar plant is under construction in Aqaba, and others are planned for Ramtha, Mafraq, Madaba and Ma'an. By the year 2000 Jordan should have 36 treatment plants serving 65 per cent of the population and producing 60 mcm of treated water each year.

The future prospects for the widespread application of water reuse in the developing world and in Western Asia depend on a number of important factors. First, the installation and use of waste water collection systems (such as sewers and pumping stations) which will provide a source of waste water. Secondly, the extent of future research into the long-term public health implications of the various ways of reusing water. The final factor is the cultural acceptance of the large-scale utilization of treated water.

A case of interest to the coastal areas of the region is where industrial effluents are discharged into the sea. This for some coastal industrial complexes, especially on the Gulf, could be a major source of serious pollution that may affect the quality of the water entering their sea-water desalination plants, and pre-treatment may be required at additional cost. Control over industrial effluent discharge and oil spills from tankers in the Gulf should be considered at the regional level. Industries that are discharging their effluent into the sea may gain greatly by considering and installing advanced effluent treatment and water recycling units.

Water discharge from sulphur mining in Iraq, and all similar industrial effluents discharged into rivers in Egypt, the Syrian Arab Republic and Iraq, a fact that has caused serious deterioration in the river streams, has to be dealt with not only in terms of simple, conventional primary and secondary treatment processes, but should also include tertiary treatment and water recycling units.

Runoff water from industry and industrial wastewater ponds, as practiced by some industries (as in the case of the important phosphate industry), constitute serious threats not only to surface water but also to groundwater. Such practices should be stopped or severely limited, and no industrial runoff water should be allowed at all. The food industry and small and medium-size industries are notorious for such practices and are widely spread in or near many towns and major cities in the region. In some cases their effluent is discharged directly into the sewer system or form part of urban runoff water. The design and installation of an appropriate wastewater treatment unit and their proper operation and maintenance should be made mandatory for all municipalities. Agro-industries should not be exempt from similar requirements and controls.

C. WATER POLLUTION PREVENTION

Water pollution prevention measures go hand in hand with waste minimization techniques. The Japanese, European and American experiences have shown that a broad range of economic benefits could be derived from such practices. These benefits are not derived from regulatory compliance, but rather from the use of state-of-the-art technologies that minimize wastage and increase the efficient use of materials and human resources. Water conservation measures can effectively reduce industrial wastewater and therefore effectively reduce industrial effluent. Alternatively, technologies which use less water or no water are to be preferred.

The available technological approaches to reduce water use in industry include using less water in manufacturing processes; using less water in cooling systems; reducing water losses from plant equipment; recondensing steam; using less water for cleaning; dewatering sludges prior to disposal and reusing that water; and recycling water within the facilities.

Water conservation and efficient water use in agriculture are effective measures in increasing agricultural production and productivity. These measures include advanced irrigation technologies, such as drip irrigation and microjet irrigation, and piping water or lining irrigation channels, to reduce loss through evaporation. Rational use of irrigation water can result not only in considerable savings in fertilizers and improved yield, but also in a substantial reduction in drainage water and thereby in water resource pollution.

Urban water supplies conservation measures, beside the proper maintenance of the distribution network system, include such technologies that allow the conservation of domestic water. Reusing domestic wastewater after adequate treatment for irrigation, toilet flushing and industrial water, monitoring water quality is essential in this case to ensure the safe reuse of domestic treated wastewater. Another important conservation measure is the use of low-quality water sources and reusing industrial wastewater after proper treatment. The economics of such uses is to balance the cost of treatment needed against the marginal costs of supplying new water.

A large number of pollution prevention techniques have been developed over the last two decades, and many of them have direct bearing on water use efficiency and water quality issues. The economic benefits for most of these technologies depend to some extent on a regulatory system that offers both incentives and avoidable costs. However, the absence of such a regulatory system in some countries, and ineffective enforcement, in general, in most countries in the region, nullify most of the economic benefits of these technologies.

Nevertheless, a significant economic savings may result from other factors, such as raw materials and energy savings, improved productivity and better product quality.

Examples of such pollution prevention techniques that have direct bearing on water quality issues in the region are given in the following paragraphs:

(a) Replacing single-pass rinse water treatment systems with closed-loop batch systems using advanced reverse osmosis techniques in the electroplating industry results in savings on the cost of wastewater treatment, deionized water production, and on the recovery of chemicals and the disposal of sludge. This is of special interest to many of the larger cities in the region where small electroplating shops concentrate in the so-called industrial sectors of these cities and generally discharge their wastewater into the city sewer system;

(b) Replacing the practice of cleaning and scrubbing metal parts with wet caustic soda and rinsing them with water in remanufacturing and restoration workshops with baking ovens and aluminium shot sprays to remove oils, grease, grime and rust for metal coating. As in the previous case, savings could be realized both in materials and operational costs. Also, such workshops are commonly found in restricted areas within large cities of the region;

(c) Wastewater ultrafiltration systems with floating oil skimmer to filter spent coolant water, scrubber, mop and process water, can recover concentrated oily waste which may be used in fuel blending, and save the municipal sewer system from the general practice of discharging oil-contaminated wastewater by such industries as metal finishing, metal-parts manufacturers and car-wash and oil-change garages;

(d) Reduction in water fines generated from the coke-cutting operation in petroleum refineries by the use of specially modified plate separators for the in-ground sump where the refinery wastewater and solids separate. This results in increased recovery of coke and reduced oil/water separation solids and substantially reduces the amount of coke fines that usually find their way into the sewer system;

(e) Installation of decanter systems in film-developing laboratories to separate chlorinated organic solvent from water which would otherwise be discharged into the municipal sewer system by hospitals, X-ray clinics and photographers' workshops. For a small capital lay-out, a considerable savings can be realized by the film developing unit in terms of recovered solvent and makeup water, as well as by reducing the amount of the undesirable chlorinated compounds finding their way into public water resources;

(f) Water pre-treatment and reuse systems installed in fruit and vegetable packing plants can realize considerable savings on wash water and the cost of wastewater treatment. Waste wash water is a serious source of water pollution because of the high content of such pollutants as pesticides, detergents, disinfectants, waxing and colouring agents, sand, soot, molds and fruit and vegetable debris;

(g) Water recovery systems installed in milk and ice-cream processing plants for pasteurizing can result in water savings as well as in recovering dairy solids and butterfat and decreasing milk losses. This is in addition to the considerable reduction in wastewater treatment costs owing to the decreased total suspended solids and biological oxygen demand (BOD) in the effluent.

D. Desalination

A study on desalination of brackish water was conducted by the ESCWA secretariat in 1986 (E/ESCWA/NR/87/12) in order to augment fresh water supplies for domestic and agriculture uses in rural areas in the region. The study was intended to propose ways and means to improve water quality and hence the living conditions as well as to maintain water supply for sustainable agricultural production and rural development.

The considerable experience gained over the past 20 years, together with improvements in desalination technology using the distillation, electrodialysis and reverse osmosis (RO) processes have made desalination a widely accepted technology. The supply of high quality water to arid areas, including most of the Gulf countries, now depends heavily on desalination processes.

Reverse osmosis and electrodialysis reversal (EDR) techniques seem to offer the most appropriate technologies for brackish water desalination in view of their simplicity of structure, ease of maintenance, operation and installation and energy-saving features; they are also the least costly desalination techniques. With regard to brackish water applications, electrodialysis is competitive in terms of capital costs and can utilize direct current electrical output without high pressure; it is also more tolerant to high water quality.

Estimates of the distribution of installed desalination plants in 1980 show that the Middle East ranked highest in the world, with 58 per cent of world capacity. In 1986, the installed water generation capacity in the Gulf subregion amounted to approximately 2.4 mcm/d. Water demand is expected to increase by as much as 50 per cent in the next 10 years. The Gulf subregion is the largest market for reverse osmosis systems. Two thirds of these systems are in Saudi Arabia alone. Desalinated water produced by other methods in the ESCWA region amounts to about 60 per cent of total world production of desalinated water.

Saudi Arabia has come to rely heavily on desalinated water. It has the largest market for desalination equipment, with a total capacity of 1 million cubic metres per day (1982 estimates), utilizing its large supplies of brackish water (BW) and sea water (SW) for potable water. The Saline Water Conversion Corporation (SWCC) has established several desalination plants on the coasts of the Red Sea and the Arabian Gulf. Total sea water desalination capacity in 1980 was 181,800 cubic metres per day, while the total generated power for dual purpose plants was about 850 megawatts. Total water production was estimated in the third five-year plan to be 1,900,900 cubic metres per day in 1987, while total power generation was estimated to be 4,300 megawatts. SWCC has commissioned the largest multi-stage flash (MSF) facility in the world at al-Jubail on the Arabian Gulf. When completed, it will have a capacity of about 1.1 mcm/d. The water produced will be pumped 485 kilometres overland to Riyadh. Saudi Arabia allocated SRls 2,192 million for desalination in the 1987-1988 budget. Kuwait, the United Arab Emirates, Qatar and Bahrain also depend on desalinated water resources for their water supply. These countries produced a total of approximately 1.5 mcm/d of desalinated water in 1981.

A combined power desalination plant was constructed at Sitra, Bahrain, in February 1986. It now produces 100,000 cubic metres of water per day and 24 megawatts of electricity. The production of desalinated water in Bahrain now accounts for 84 per cent of its total fresh water consumption. A 10 million gallon a day water reverse osmosis plant has been recently constructed in Bahrain and is the world's largest facility of its kind.

Oman's Ministry of Electricity and Water recently built a 27,000 cubic metres per day MSF plant which now supplies water to an area near the capital city of Muscat.

Because of its high cost, desalinated water is generally used for domestic consumption and certain industrial uses; it is not generally used in agriculture. There is, however, considerable potential for introducing small-scale desalination plants to treat brackish water in remote and rural areas in the ESCWA region. Renewable energy (solar and wind) is often a viable power source for such facilities where alternative supplies are extremely limited. The first solar-powered sea-water reverse osmosis facility was installed in 1981 at a community outside Jeddah, Saudi Arabia, and has provided about two cubic metres of high-quality drinking water per day. A six cubic metres per day unit has also been built in Qatar, and efforts are being made in Egypt and Jordan to promote this type of desalination technology. Small-scale desalination units powered by solar photovoltaic systems are adequate for remote areas in the ESCWA region.

ESCWA member countries that are active in the field of both sea and brackish water treatment are the Gulf countries, including Bahrain, Kuwait, Qatar, Oman, Saudi Arabia and the United Arab Emirates. Desalination started in these countries in the early 1950s.

E. SEA-WATER INTRUSION CONTROL MEASURES

Intrusion of sea water into coastal aquifers is the most pollutant in fresh groundwater. Usually, intrusion of saline water (sea or brackish water) occurs where saline water displaces or mixes with high quality water in an aquifer. Such a phenomenon can also occur in deep aquifers with the upward advance of saline water of geologic origin.

Sea-water intrusion into fresh groundwater may have several causes, but in the ESCWA region may be attributed to:

(a) Encroachment of seawater onto coastal areas;
(b) Water that was originally saline;
(c) Return flows from irrigated flows;
(d) Human saline wastes.

Usually saltwater intrusion takes place via three mechanisms:

(a) Reduction of reversal of groundwater gradients, which permits denser saline water to displace high quality water, such a mechanism is usually produced in shallow coastal aquifers in hydraulic continuity with the sea when pumping of wells disturbs the natural hydrodynamic balance (United Arab Emirates, Qatar, Bahrain and Oman);

(b) Destruction of natural barriers that separate fresh and saline waters, as in the case of construction of a coastal drainage canal that enables tidal water to advance inland and to percolate into a freshwater aquifer;

(c) Subsurface disposal of waste saline water, such as disposal in wells or landfills.

There are many examples of intrusion in the ESCWA region. Therefore, sea-water intrusion along the coast has received the most attention in regional coastal aquifers consisting of Karstic limestone (Egypt, the Syrian Arab Republic, Lebanon and the Gaza Strip). Irregular fissures and other openings enable sea water to enter the aquifer in configurations that may differ from those homogeneous aquifers.

Remedial methods for controlling coastal aquifers in the ESCWA region vary widely depending on the extent of the intrusion, the local geology, water use and economic factors. Measures for coping with sea-water intrusion are:

(a) Modification of the pumping pattern via the relocation of pumping wells by dispersing them in the land area can help in re-establishing a stronger seaward hydraulic gradient. Reduction of pumping of the existing wells can produce the same beneficial effect;

(b) Artificial recharge was originally meant to maintain or augment the natural groundwater as an economic resource, and to combat adverse conditions such as progressive lowering of groundwater levels and sea-water intrusion; in addition, it provides treatment and storage for treated wastewater reuse. Though artificial recharge is meant as an operation of water conservation, it also assists in overcoming problems associated with overdraft. Accordingly, in sea-water intrusion controls, groundwater levels can be raised and maintained by artificial recharge, using surface spreading for unconfined aquifers and recharge wells in confined aquifers. The case of Qatar is an example of using artificial recharge for maintaining the hydraulic gradient along the interface;

(c) There are measures to control sea-water encroachment which are not in use in the ESCWA region, such as:

(i) The extraction barrier: to create and maintain a continuous pumping trough with a line of wells adjacent to the sea;

(ii) Injection barrier: to create a pressure ridge along the coast by a line of recharge wells;

(iii) Subsurface barrier: to construct an impermeable subsurface barrier parallel to the coast and through the vertical extent of the aquifer which can effectively prevent the inflow of sea water into the basin.

Case-studies are demonstrated below.

1. The Batina coastal plain - Oman

The Batina coastal plain lies in northeast of Oman. The plain itself is bounded on the northeast by the Arabian Sea and on the southwest by the Northern Omani Mountains. It is dissected by shallow wadi systems that extend into the Northern Omani Mountains (figure I). Rainfall is very low and is subject to great temporal and spatial variability. The mean annual rainfall ranges from around 50 mm to 200 mm. Reliable freshwater resources exist only as groundwater, typically in shallow alluvial aquifers in the wadi systems that drain the mountains.

Over the last 20 years, subsidized extensive agriculture has been developed on the plain. Serious depletion of aquifers owing to increasing abstraction of the shallow unconfined aquifers besides the prevailing extended dry periods. Figure I indicates that groundwater quality deteriorates in the direction of the general flow. Salinity ranges from 1,000 ppm (fair quality) near the foothills to more than 10, 000 ppm near the coastal plain. Monitoring wells spreaded over the plain indicate that groundwater of low salinity diminishes near the coast, which is attributed to sea-water intrusion.

On the Batina coastal plain, most solutions to water quality deterioration that resulted from sea-water invasion focus on water resources management. These include dam construction upstream to increase recharge groundwater, demand management (demand reduction to allow freshwater to balance the salty/fresh water interface) and legislation to control groundwater withdrawal (42).

2. Sidi Kreir (South Mediterranean), Western Desert, Egypt

The South Mediterranean is characterized by a narrow coastal zone 1,000 km long from east to west and 20 km wide from north to south (mean sea elevator ranges from 700 m to more than 1,000 m). The annual rainfall ranges from 150 mm to 300 mm. The coastal plain that bounds the Mediterranean (around 50 m above mean sea level) is of a calcareous nature. A lagoonal depression with a number of standard ridges marks the coastal plain as being of the Quaternary age. Around 200 intermittent streams dissect the coastal plain, and a shallow free aquifer system dominates.

The freshwater exists in the form of a thin aquifer situated above the saline water. The overpumpage withdrawal is located to the south and corresponds to the Herzberg hydrostatic condition of groundwater (mining). The result is that the interface between freshwater and salt water is moving away from the coastline inland direction and allowing the upward movement of salinization of the groundwater to take place in the plain.

Figure II shows Sidi Kreir on the Mediterranean with isolates and main morphological calcareous features. It indicates the mechanism of sea-water intrusion along the plain. The case of Sidi Kreir is influenced by the intrusion of waters from the Mediterranean side to the north and of hyper-saline water from Mariut Lake (43).

Professor Abdu A. Shata of Egypt's Desert Research Centre suggested solutions such as optimum water conservation and utilization, water conservation techniques to reduce runoff into the sea and into lagoonal lowlands, introduction of modern techniques of double pumping to create equilibrium between fresh and saline water, artificial recharge, and wide use of brackish water in irrigation and introduction of salt-tolerant crops (43).

Figure I. Hydrogeological district of Batina/Oman (46)

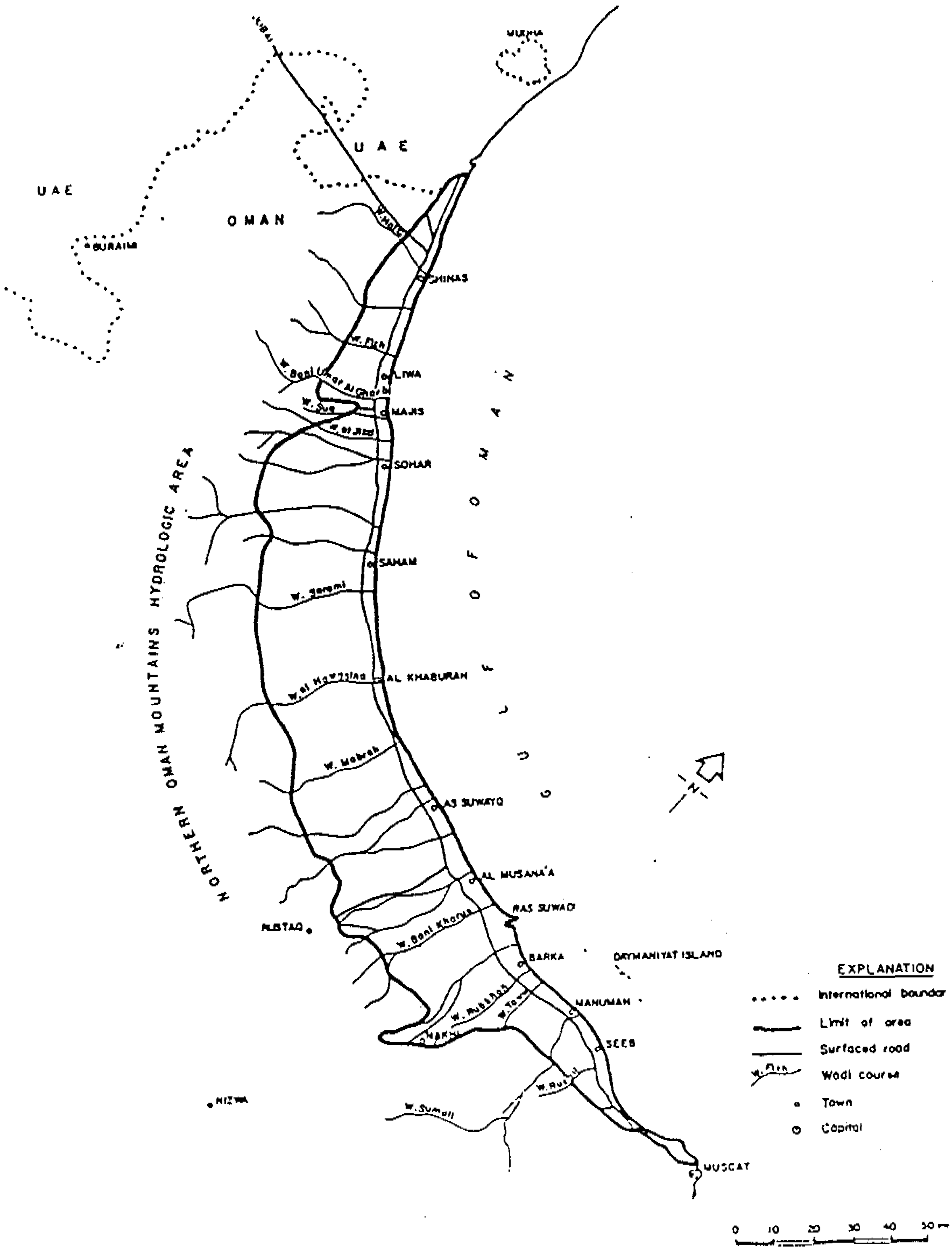
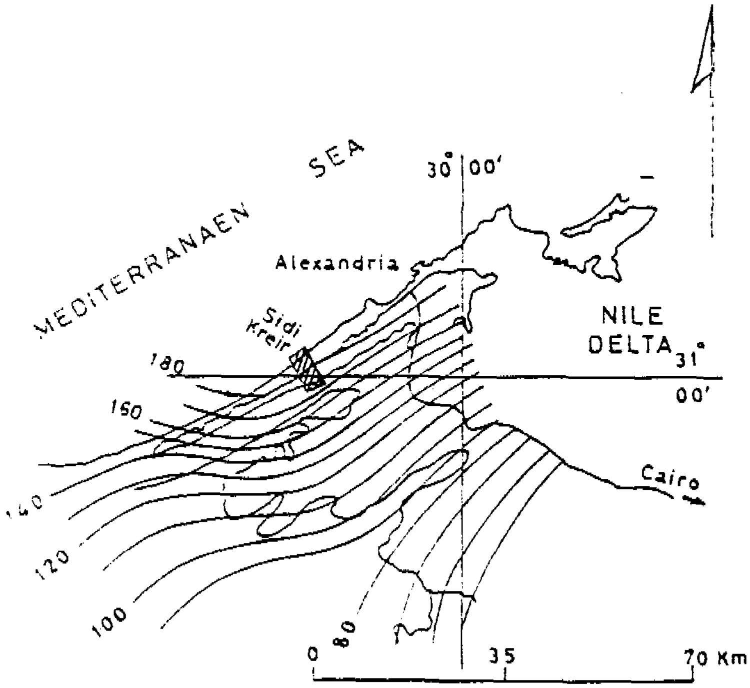
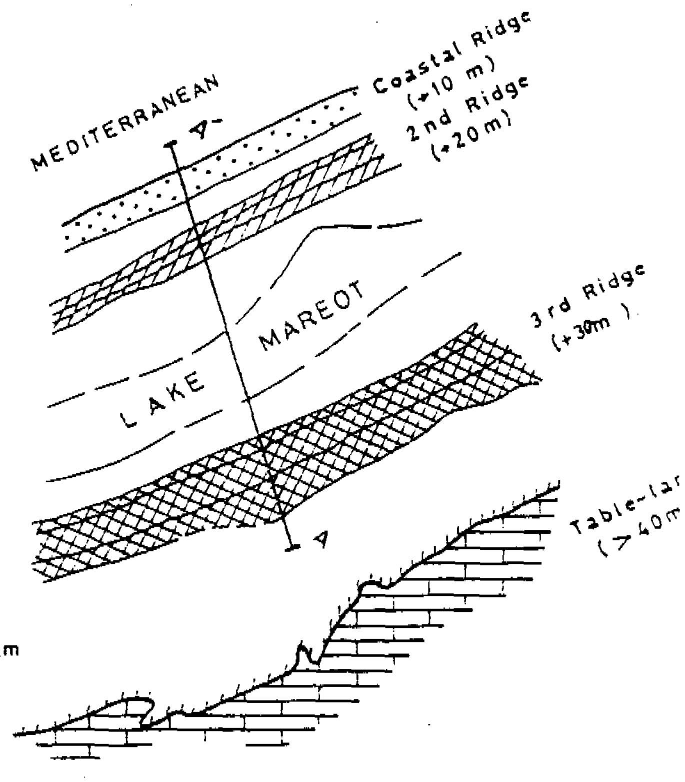


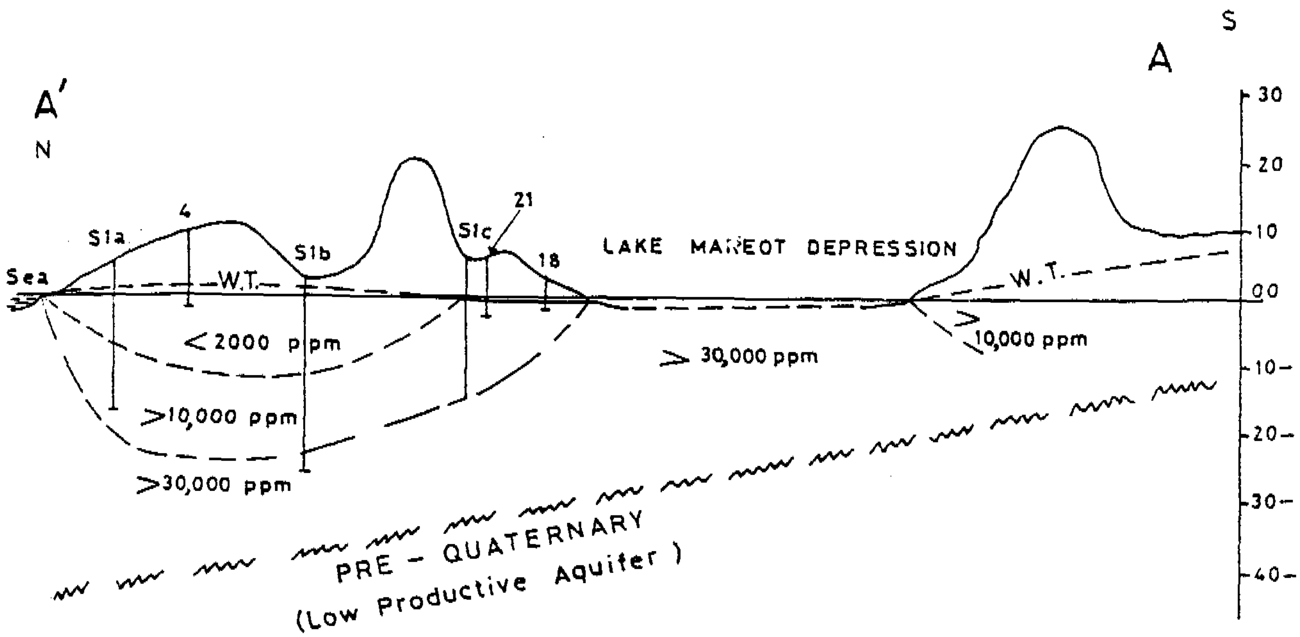
Figure II. Sidi Kreir (43)



Location Map with Isohytes



Morphological Features



Hydrogeological Profile

V. CASE-STUDIES ON WATER QUALITY ISSUES

The case-studies presented here are aimed at focusing attention on some of the water quality issues of special importance to the region. Some selection has to be made, and the cases reviewed claim no order of priority. However, they all reflect not just a country problem, but also a regional issue and therefore deserve to be considered worthy of more detailed and in-depth studies than these summaries, which are meant simply to highlight their significance to water quality issues in the region. Some recommendations are therefore ventured during the presentation of these case-studies.

A. THE USE OF AGRICULTURE DRAINAGE WATER FOR IRRIGATION IN EGYPT

The percentage of water used for agriculture in the region is over 80 per cent, and for Egypt it is among the highest. Figures have been quoted to vary between 84 per cent and 88 per cent for the period 1990-1992. The measured agricultural drainage water out of the irrigation system in the Nile Delta amounts to more than 25 per cent, which is run through an extensive drainage network to the Mediterranean Sea and the Northern Lakes.

The total amount of drainage water discharge depends on such factors as the water released at Aswan, cropping patterns and irrigation efficiency. Over the period 1984 to 1990, the drainage water discharged into the sea as a percentage of the Nile water released from the Aswan High Dam varied from 21 to 25 per cent. This amounted to 12-14 bcm of agricultural drainage water lost annually to the sea.

The salinity of the agricultural drainage water ranged between <1000 ppm to >3000 ppm, with about 74 per cent of this water containing less than 3000 ppm, as shown in table 14.

TABLE 14. AGRICULTURAL DRAINAGE WATER QUALITY IN THE NILE DELTA (1986-1987)

	Quantity		Salinity/ppm
	1.86	13.6	<1000
	4.86	35.6	1000-1500
	2.58	18.9	1500-2000
	0.80	5.9	2000-3000
	3.53	25.9	>3000
Total	13.63		

Source: United Nations Economic and Social Commission for Western Asia, "Proceedings of the Ad Hoc Expert Group Meeting on Water Security in the ESCWA Region," E/ESCWA/NR/1990/3, Damascus, November 1989.

Agricultural drainage water may be used directly without mixing with fresh Nile or canal water when the salinity is low, or it can be mixed with fresh river water when the salinity is high.

However, there are several factors that could affect the salinity of the drainage water besides the quantity of water released from Aswan and irrigation efficiency. Important among them is the fact that an increased amount of reusable drainage water could also contribute significantly to the salinity problem. Nevertheless, the amount of drainage water reuse is further limited by the need to discharge a substantial portion into the sea in order to minimize the salt content in the Nile Delta.

The use of agricultural drainage for irrigation in the Nile Delta formed part of the 1987-1992 five-year plan. It is estimated that 2.9 bcm were used annually before 1987, and the figure had risen to about 5.9 bcm by 1993. The amount of drainage water reuse is expected to increase to about 8.5 bcm/yr by the year 2000.

The expansion in the reuse of drainage water for irrigation would require careful control over the salinity level as well as its possible contamination with municipal wastewater and industrial effluents. Another factor that has to be carefully dealt with is the increased amount of organic and inorganic toxic pollutants that could find their way directly into the agricultural drainage system from the use of fertilizers and agrochemicals, as well as from runoff from rural refuse dumps. Therefore, a carefully planned water quality monitoring system must be specially designed and made operational, with a well-thought-out extension service to prevent possible misuse of this important source. The extent to which polluted drainage water can be reused with or without mixing with fresh water will have to be carefully monitored.

Plans for the proper use and conservation of this source of irrigation water must be expeditiously put into action. Options for cleaning up this important source, as well as municipal and industrial effluents, need careful consideration in the light of the eminent water shortage that Egypt will face at the end of the first quarter of the twenty-first century.

The reuse of agricultural drainage water is of great relevance to the region with its agriculture claiming the highest share of the available water. Drainage water reuse should fare prominently in the water policy of the region. Careful assessment of the Egyptian experience in this field should therefore be considered a regional issue of primary importance. Among the many questions to be specially considered is that of water quality monitoring and the requirement to preserve the water-soil salinity balance.

B. Pollution problems with the Euphrates in Iraq

The Euphrates is one of the major rivers in the region. As previously mentioned, originating in Turkey, it flows through the Syrian Arab Republic and then Iraq where it meets with the Tigris to form Shatt al-Arab, north of Basra, and finally discharges into the Gulf. The total length of the river is 2,900 km, of which 1,100 km is in Turkey, 600 km in the Syrian Arab Republic and 1,200 km in Iraq. Notwithstanding the international character of the Euphrates, there is as yet no agreement among the riparian States on the rights to the river's water.

The construction of major dams on the river with massive storage capacities, of 89 bcm in Turkey and over 15 bcm in the Syrian Arab Republic, caused serious decrease in the flow of the river into Iraq. This is expected to affect drastically the quality of the Euphrates water entering the Syrian Arab Republic and more so when it enters Iraq, especially during drought seasons. Thus, while water salinity used to vary between 200 and 400 ppm for the river on entering Iraq, it has exceeded 1000 ppm in recent years.

As part of its water strategy, Iraq has built on the upper Euphrates the Haditha Dam and Reservoir, with a capacity of 11 bcm. To offset the shortage of water in the central and southern reaches of the river, the Tigris-Euphrates water transfer project was executed, whereby water from the Tharthar Depression, fed by excess flood water from the Tigris is carried by the Tharthar-Euphrates Canal into the Tharthar Depression during dry seasons. The capacity of the Tharthar Depression is about 72 bcm, and water stored in it showed increased salinity because of surface evaporation as well as from the soluble rock and soil formations of the depression.

The combined effect of all these factors led to the progressive increase in the salinity of Euphrates water, especially in the central and southern reaches.

Another deleterious effect on the water quality of the Euphrates is brought about by the mushrooming industries that have spring up on or near the river basin along its entire length within Iraq. In most cases these industries were built with little or no consideration to the control of their wastewater, which found its way directly or indirectly into the river. Examples of industries that can be considered as major cause of river pollution are: the phosphate industry; the cement industry; a glass factory; a rayon factory and a chlor-alkali plant; a mechanical industries complex; the automotive industry; a chemical industries complex; the textile industry; the wire and cable industry; the aluminium foundry and aluminium tube industry; electrical power plants; and petroleum refineries.

Although the environment protection law mandates environmental monitoring and the protection of water resources, little has been planned or done to impose controlling measures on the effluents of these industries, and for some of them environment impact assessments have never been done.

An effect of equal importance, to which the rising river-water salinity is a major contributor, is the increased soil salinity in the central and southern plains of the Euphrates basin. Coupled with the deteriorating water quality, and made worse by the water shortage, the agricultural production, in some of the otherwise richest crop fields in the central Euphrates, has declined sharply.

An important component of Iraq's development plans was land reclamation and desalination. Iraq has an extensive agricultural drainage network which runs for more than 85,000 km in addition to the 576-km-long major drainage canal that discharges into the Gulf, which was recently completed. Besides its role as a drainage canal, it is expected to seriously affect the surface waters of the marshlands in southern Iraq, among which are those along the lower Euphrates.

The situation has, of course, been made worse by the destruction of many of the factories along the Euphrates during the Gulf war. The great damage that most of them suffered, exposed the environment in general, and the Euphrates basin in particular, to a serious pollution situation involving the emission of toxic substances into the air, soil and water.

This is a prime example of a "damaged" environment for which carefully planned and prompt remedial action is necessary. Water quality monitoring can only form a part, albeit essential, of such action.

The importance of this issue to the region is glaringly apparent in that, if properly managed, this represents a first-hand example of how to salvage and repair a damaged environment and how to clean a heavily polluted water source.

C. Remediation of hydrocarbon-polluted water

The protection of water resources from hydrocarbon pollutants, especially from the petroleum industry, should feature prominently in a region with one of the world's highest levels of oil production and reserves. Both ground and surface waters are susceptible to hydrocarbon pollution. The toxicity levels of some of these pollutants have made them second-to-none with respect not only to humans and animals but also to plants and aquatic life.

Another aspect of the problem which should be of interest to petroleum-producing countries is the considerable amount of water associated with the production of petroleum, so-called "coproduced" water. Typically, two barrels of water are coproduced with every barrel of oil. Some of this water may contaminate both ground and surface waters. In addition, hydrocarbon-contaminated waters in such large quantities in a region suffering from water scarcity present a challenging alternative non-conventional source of water that deserves serious and close consideration for possible utilization.

The quality of coproduced water varies widely depending on the characteristic of the oil-field; both the type of water and the oil with which it has been in contact, as well as the conditions of temperature, pressure and the geological formations, are all important factors. In general, however, the major contaminants are organics (both aliphatics and aromatics in dissolved as well as in colloidal form) and organic and inorganic salts. The inorganic salts vary considerably from salinities more concentrated than sea water to only slightly brackish water.

These variables have to be carefully assessed before any serious consideration for the utilization of these waters is contemplated. A remediation strategy to produce quality water suitable for a particular use has to be carefully planned. However, comparative studies of alternatives must be undertaken, such as industrial effluents and municipal wastewater treatment to produce water suitable for irrigation *vis-à-vis* treated coproduced water. The advantage of the latter is that coproduced water is free from pathogens and thus allows for wider uses of the treated water.

In this respect, remediation processes, especially advanced water treatment technologies, offer attractive possibilities to obtain "high" quality water for a wide range of uses. Since both organic and inorganic substances are to be removed, the treatment strategy must be planned so as to achieve a level of quality appropriate to the intended uses of the coproduced water. Equally important, the choice of technology will also be dictated by the origin of the coproduced water and the type and level of pollutant to be removed.

In the techno-economic evaluation of the proposed treatment, due consideration must be given to the environmental impact of the chosen technology. In that respect, the advanced oxidation processes for the removal of organic matter have a clear advantage over the other available technologies, such as activated carbon adsorption. In the adsorption technology, the disposal of the solid spent carbon waste poses a serious environmental problem.

D. King Talal Dam/Jordan water quality problem

The King Talal Dam is situated at the mouth of a 3,000 square kilometre catchment area (figures III and IV). Its capacity is 80 mcm. The dam was originally designed for irrigation purposes to expand the cultivated area in that catchment area. The catchment area is considered heavily populated with a high rate of industrial activity and a moderate cultivated area. The Zarqa River usually starts flowing in Amman passing through Ruseifa, Zarqa and Sukhneh. Special emphasis was made to the quality of the water impounded behind the dam, which caused diverse reactions among specialists.

The question of the implication of water quality for human health was raised. Undoubtedly there was ground for the anticipated concern. This is mainly attributed to:

(a) A substantial pollution load reaches the dam reservoir from domestic and industrial wastes as the catchment area is heavily populated and of high industrial zoning;

(b) Eutrophication of dam waters by major nutrients is taking place. Fertilizers used in irrigation are the main source of such nourishing elements. Sewage effluents contain amounts of nutrients such as phosphorous, nitrogen, iron and trace elements. This is indicated by the following analyses of sewage effluents (44).

However, the "National Environment Strategy for Jordan", issued by the Ministry of Municipal and Rural Affairs and the Department of the Environment in 1990, describes the situation in the King Talal Reservoir and its catchment area in the following manner: "The Zarqa River is contaminated with industrial wastes that include mercury, nickel, arsenic lead, selenium and cadmium. These are the main pollutants of the Zarqa River and the King Talal Reservoir which is constructed on it. In addition, waste water effluent from the Khirbet Al Simra Treatment Plant is discharged to the Zarqa River. Industrial waste water suitable for discharge must comply with the Stringent Standard Specification No. 202. However, these specifications are not applied, and subsequently the Zarqa River and King Talal Reservoir are heavily polluted. Based on experimental work carried out in London, it is advised that the King Talal Reservoir not be used under any circumstances for potable water, unless substantial improvements are made to upgrade the raw water quality."

Analyses of industrial waste water in the Zarqa-Ruseifa areas are shown in table 15.

TABLE 15. ANALYSIS OF INDUSTRIAL WASTE IN KING TALAL DAM

Constituent analysed	Concentration range (mg/l)	
	1	2
Magnesium, Mg	2.4 - 1143	4.8 - 189.6
Calcium, Ca	0.0 - 6012	7.2 - 840
Potassium, K	5 - 900	35.2 - 305
Sodium, Na	44 - 7500	52.9 - 3496
Chloride, Cl	50 - 37204	97.6 - 1615
Total dissolved solids, T.D.S.	520 - 59785	592 - 7596
Phosphate, P2 O5		
Sulphates, SO4	Trace - 35	Not analysed
Nitrate, NO3	0.2 - 4167	0.00- 2277
Chemical Oxygen Demand	Not analysed	3.7 - 705
Iron, Fe	Not analysed	1.9 -46256
Copper, Cu	.005 - 27.0	0.34- 1.3
Lead, Pb	.005 - 1.0	0.01- 3.5
Nickel, Ni	.05 - .45	0.019- 0.45
Aluminum, Al	.03 - 7.6	0.023- 0.03
Zinc, Zn	.01 - 15	Not detected
Cadmium, Cd	.035 - 0.3	0.039- 1.06
Manganese, Mn	.01 - 0.5	0.00 - 0.02
Chromium, Cr	.01 - 1.03	0.08 - 0.5
Mercury, Hg	2.0 - 8.0	0.009- 0.01
PH	3.1 - 11.2	Not analysed 2.6 - 11.4

1- Royal Scientific Society Laboratory, Jordan.
2- Natural Resources Authority Laboratory, Jordan.

Source: R. Gedeon and N. Shalbak, report to the First Jordanian Water Symposium, Amman, 1989.

In a report to the First Jordanian Water Symposium held in Amman in 1989 (44), the following substantial improvements to be made were proposed:

(a) A professional unit should be immediately set up to direct and supervise control activities in the Zarqa River Basin in order to preserve the highest possible quality of water at the King Talal Dam; an environmental study of the basin must be urgently planned and implemented;

(b) Training programmes for water and sewage works operators should be established and employees encouraged to participate in them;

(c) Participation in international efforts at water control should be actively pursued;

(d) Comprehensive legislation on pollution control should be formulated and implemented; standards on all aspects of water control should be adopted;

(e) A water quality network should maintain a constant check on water pollution. At the start, analysis of water, at least once a month at well-defined points along the river must be initiated, for example at dam site, at the new Jerash Bridge, opposite Sukhna, at the Zarqa Bridge and at the Ruseifa Bridge. At the dam site, a number of suitably located sampling stations have to be considered. The proposed analyses must cover physical, biological and chemical qualities. A quality control laboratory at the dam site would be an asset for the monitoring programme;

(f) The river basin should be considered as one unit. A programme for water quality management must be developed. This may require a period of three to five years from the start of planning;

(g) Adequate measures should be adopted to ensure that waste waters discharged into the river are in compliance with the established standards;

(h) Authorization of new industries in critically polluted areas should be banned until the current conditions are resolved. The available industries must be forced by law to meet their obligations;

(i) Control over pesticide use in the region has to be integrated with protection measures.

Figure III. Major industrial locations (Amman-Zarqa area) (44)

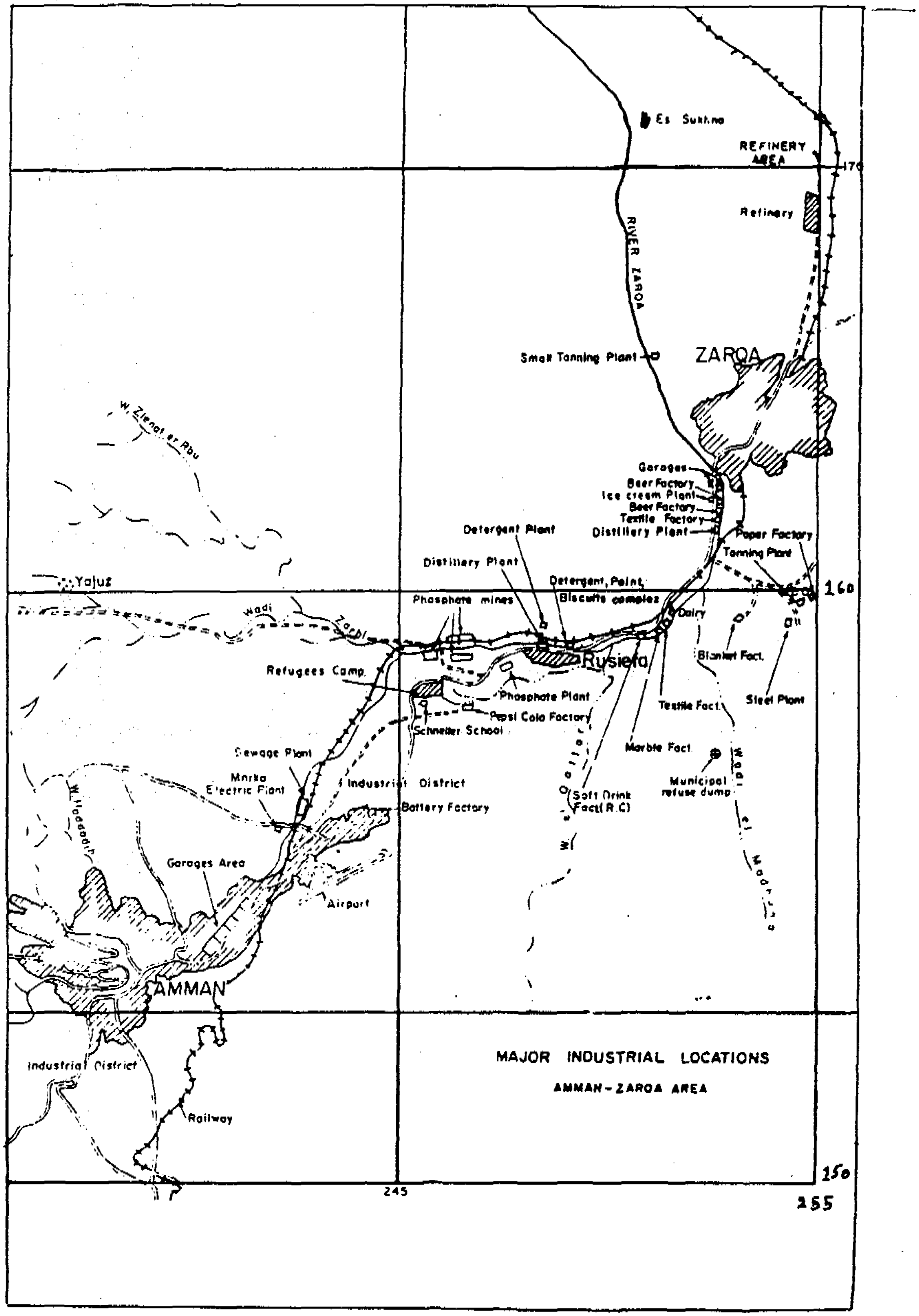
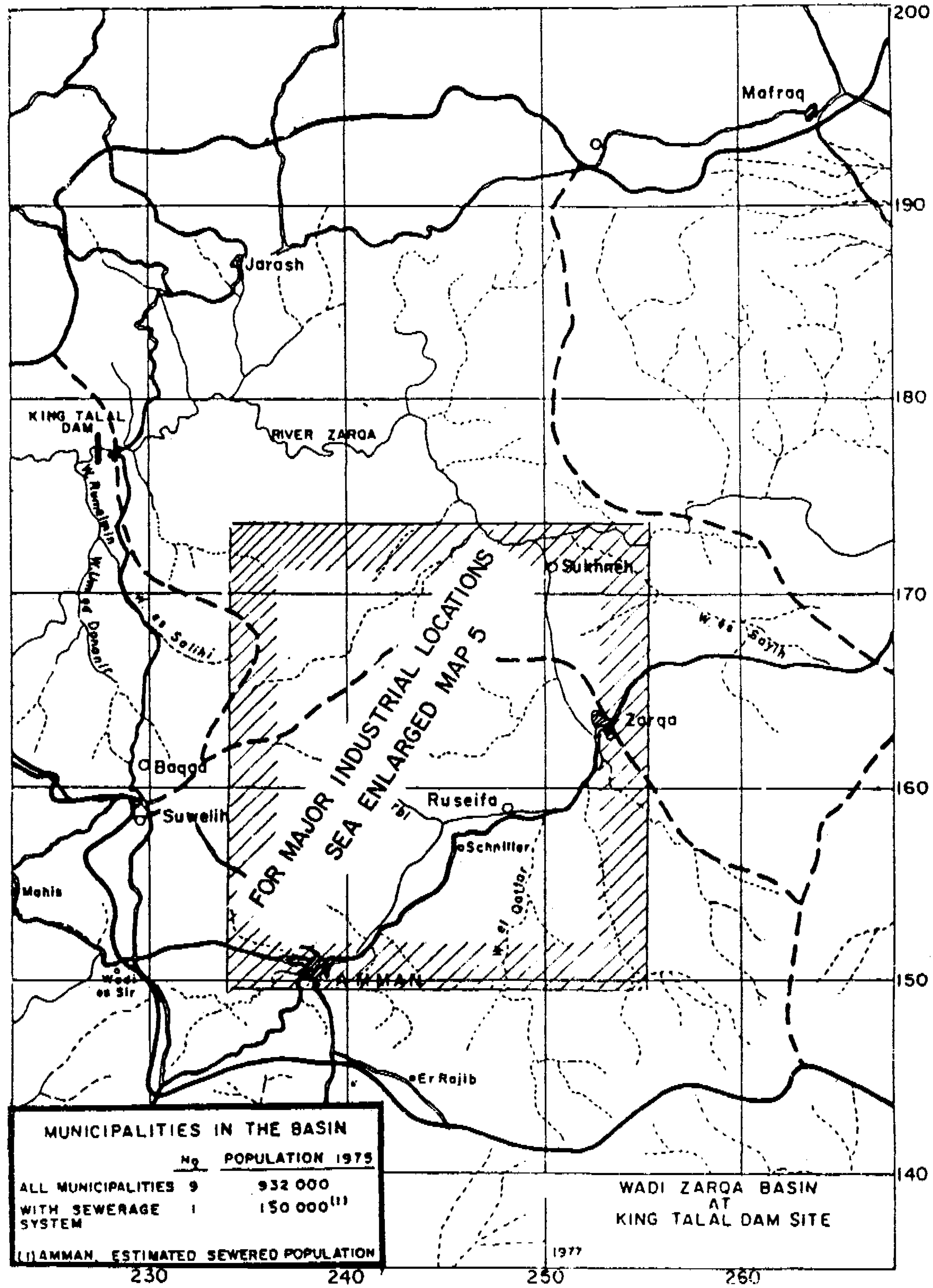


Figure IV. Wadi Zarqa basin at King Talal Dam site (44)



VI. CONCLUSIONS AND RECOMMENDATIONS

The countries of the ESCWA region, with their high rate of population growth, almost explosive urbanization, and rapid industrialization, coupled with serious overdraft conditions as regards their water resources and unsolved problems of shared water basins among riparians, are living through the sequence of water quality issues with neck-breaking succession. Furthermore, they are doing so over a short period, as compared with over a century and half that the developed industrialized countries have taken to face the sort of problems currently afflicting the ESCWA region. Thus, situations have arisen in many ESCWA member countries in which more advanced pollution issues appeared before control over traditional pollution sources had been successfully achieved. The people of the region know that they must give the highest priority to ensuring the satisfactory supply of "good" quality water that is so essential to their sustainable development. Therefore, with their water-poor region, they must exercise the greatest care in sustaining their water resources both quantitatively and qualitatively. The question of water quality and water quality control is a pivotal one that requires quick action in setting up the most effective water action plan, involving not only the much needed modern legislation but also viable management and organization.

Currently there is a focus on many regional plans and policies prepared on the water resources of the region. The issue of water quality was considered to be one of the three priority issues identified for action in the region. The inadequacy of water quality monitoring in the region, together with the institutional incapabilities and the lack of legal and regulatory prowess, were duly identified. These observations were frequently recorded in many regional and national gatherings on water resources in the ESCWA region. The problem of degradation and depletion of water resources was identified as being of the highest priority among the environmental constraints in the region. A strategic objective of the regional plan is water quality improvement and efficient water use, which comes under one of the main goals of sustainable development.

An analysis of water resource problems identified the following problem areas to be of greatest concern:

Water shortages resulting from inefficient use;
Degradation of water quality;
Ineffective public- and private-sector water resource management.

The following strategic objective components were defined:

Increase effective use of water;
Enhance water quality;
Improve water management.

It is now obvious that water quality is deteriorating all over the region, in various ways disturbing the usability of water. Common issues have been identified within the ESCWA region regarding the water quality as sources of water resources degradation.

(a) Pathogen agents from faecal discharge, probable to become more severe as population increases more rapidly than waste water collection and effective treatment are implemented;

(b) Organic pollution from the same sources, consuming the oxygen in receiving water bodies with consequential effects on biological life;

(c) Salinization, primarily by poorly managed irrigation systems in the regions, one of the primary water quality problems in overexploited coastal aquifers; and as a result groundwater mining activities;

(d) Nitrate pollution of aquifers, particularly shallow aquifers, from surplus fertilizers and from human activities;

(e) Eutrophication caused by increasing levels of nutrients, normally phosphate but sometimes nitrate;

(f) Heavy metals, of which only a small fraction has yet leached into water bodies, but the amount may rise owing to rain acidification;

(g) Pesticides, the use of which has risen exponontially during the last two decades, but the contamination of which remains poorly documented owing to analytical difficulties;

(h) Industrial organic substances such as solvents, chlorinated hydrocarbons, and polycyclic aromatic hydrocarbons from air exhausts, dump site leakage, and waste waters;

(i) Acidifying substances released in air exhausts as inorganic acids and causing acidification of aquifers, rivers and lakes in poorly buffered regions such as those with sandstone and crystalline rocks, and associated with increases in dissolved aluminium and certain other metals;

(j) River sediment loads which have increased considerably owing to erosion caused by man causing enormous turbidity problems locally, and in general disrupting natural biological processes in rivers and coastal areas.

Human activities in the region also involve modifications of natural hydrologic regimes, with various direct effects on water bodies: salinization of rivers, lakes and soils; salt intrusion in coastal aquifers; and reduced dilution and self-purification capacity of rivers.

In the light of the developments of the last three decades, the laws and regulations which were effective half a century ago have become completely ineffective. The authorities responsible for water control continued to operate along traditional lines, with marginal changes brought about on an ad hoc basis. These authorities concerned themselves mainly with ensuring a minimum level of safety in the water supply, mainly with respect to the absence of pathogenic contaminants. Their role *vis-à-vis* the misuse of water sources was limited to preventing the discharge of raw domestic wastes into the mainstreams. Hardly any control was exercised over the discharge of industrial effluents or of inadequately treated wastewater. The question of the degradation of main water resources, surface or ground waters, owing to agricultural drainage or the contamination arising from toxic agrochemicals, was seldom considered.

The situation is further complicated by the fact that in many countries of the region responsibilities for water resources are divided among various governmental and public departments with, in some cases, no central authority responsible for all aspects or the water sector. Thus, there seems to be no single body responsible for water quality management. Water quality issues are dealt with in an ad hoc manner by the different ministries. Water authorities as such mainly handle water distribution systems and treatment, such as disinfection of water supplies, if needed. The level of technical competence and the inadequate training have made it difficult for the water authorities to tackle the problems arising from water resource degradation in most countries of the region. However, recent interest in environmental issues and especially in the impact of development on the environment, has led to greater attention being paid in most countries of the region to the question of water resource pollution. Consequently, this is expected to lead to the enactment of environmental quality standards, especially water quality standards.

So far, the responsible authorities in the region have accepted international standards, and specifically the World Health Organization standards in most cases. This must be viewed with caution because of the important differences and peculiarities of the region and the ESCWA member countries with respect to most environmental problems, not least among them are the climatic and soil conditions. To this must be added the socio-economic and environmental requirements for sustainable development in the region. All this must emphasize the need for an endogenous water system built upon a clearly stated national and regional water policy. Water quality, in all its aspects, can only be considered rationally within the framework of a system that recognizes the realities of the water situation as part of the socio-economic and geopolitical milieus of the region.

The situation may be summarized in the following terms:

(a) Legislation has not developed sufficiently to meet the level of technological advancement made in many of the socio-economic sectors;

(b) The absence of a national policy on water quality that can serve as a basis for water quality standards;

(c) The organizational set-up is inadequate to handle the demands for the quantity and quality of water required by a rapidly growing and advancing society.

The World Health Organization, as well as other organizations, is taking an active role in developing guidelines to describe water quality to satisfy economic and consumer health considerations. These guidelines stimulate the importance of analytical monitoring of drinking water quality to avoid ingestion of pollutants such as chemical contamination and bacteria. In 1984 WHO introduced Drinking Water Quality Guidelines (three volumes) superseding both the European Standards and International Standards for Drinking Water which had been in existence for over a decade. The main reason for replacing the previous standards for drinking water quality was the desirability of adopting a risk-benefit approach to the national standards criteria, standards and regulations. Adoption of excessively stringent drinking water standards could limit the availability of water supplies that meet those standards. Hence the WHO Guidelines for drinking water quality were set instead of WHO standards for use by countries as a basis for the development of their own national standards, which, if properly implemented, would ensure the safety of the drinking water supply.

It has been emphasized on many occasions that the WHO Guidelines are not standards in themselves but recommended levels for water constituents and acceptable contaminations. Therefore, many ESCWA member countries have set their guidelines in line with the WHO Guidelines for drinking water quality. These levels stimulated the continuous need and importance of analytical monitoring of drinking water quality to avoid ingestion of pollutants such as chemicals and bacteria. This prompts the necessity for water quality follow-up in the laboratories.

In the ESCWA region, drinking water quality has received great attention in recent times, not only because of the rise in demand but also because of the degradation of the usual sources of water for public supply. Every effort should be directed towards achieving a drinking-water quality that is as high as practicable. Protection of water supplies from contamination is the first line of defence. Source protection is almost invariably the best method of ensuring safe drinking water and is preferable to treating a contaminated water supply to render it suitable for consumption.

Water used for agriculture must be of a certain quality and adequacy for irrigation. Using lower quality water requires adapting careful planning to ensure that the available water is put to the most appropriate use. Such planning involves taking into consideration soil and crops in selecting alternatives to cope with potential water quality-related problems that might reduce production under prevailing water quality use. Water characteristics usually influence its suitability for specific uses. In irrigation water, emphasis is mainly placed on chemical and physical characteristics, and rarely are other factors considered important. In this regard, river water loaded with sediment is very useful in irrigation but unacceptable for municipal use without proper treatment.

Of the total amount of water used in the ESCWA region, 70 per cent to 80 per cent is used for agriculture. The so-called green revolution of the 1970s in developing countries, including ESCWA member countries, brought several million hectares of land under cultivation by irrigation. Irrigated agriculture plays an important role in producing food in the region. Water used for irrigation often contains some salts which sometimes may be necessary for the growth of the crop. Often low-saline water in irrigation systems may cause soil permeability problems. Therefore, a particular source of water is good for irrigating a particular type of crop in specific soil is determined by the amounts and types of salts present in the water.

Generally, the use of poor quality water for irrigation results in salinity, permeability, toxicity and other effects. There have been a number of different water quality guidelines related to irrigated agriculture. Each was useful in certain aspects but none has been entirely satisfactory because of the wide variability in the field conditions. FAO developed guidelines for interpretation of water quality which relied heavily on previous ones but were modified to give more practical procedures for evaluating and managing water quality-related problems of irrigated agriculture.

As previously mentioned, irrigation is one of the main agricultural consumers of water in the ESCWA region. Poor quality water may affect irrigated crops by causing accumulation of salts in the root zone, by causing loss of permeability of the soil owing to excess sodium or calcium leaching or by containing pathogens or contaminants which are directly toxic to plants. When the presence of pesticides or pathogenic organisms in irrigation water does not affect plant growth and in turn affects the acceptability of the agricultural product, FAO guidelines, adapted in the ESCWA member countries, take into account such characteristics as crop tolerance to salinity, sodium concentration and phytotoxic elements. Sodium in irrigation water (Jordan and the Syrian Arab Republic) can adversely affect soil structure and reduce the rate at which water moves into the soil. However, water quality guidelines in the ESCWA region, may be considerably adjusted (Egypt, Iraq and the Syrian Arab Republic) owing to different annual application rates of irrigation water.

Hence, water shortages and water quality problems together characterize the ESCWA region. In general, the countries of the region have many issues in common pertaining to water, among which are the following:

(a) The increased deterioration of water quality and degradation of water resources coupled with explosive urbanization, rapid industrialization, and uncontrolled expansion of irrigation and of indiscriminate use of agrochemicals in agriculture;

(b) The diversity of institutions and authorities in charge of water affairs in most countries of the region, and the absence of a well-defined water policy and a national water plan;

(c) The inadequacy of the present legislations or sometimes the absence of legislation in confronting the problems of water quality, and the ineffective enforcement of the existing regulations;

(d) Water quality standards are almost outdated. Those which are being put in use are either international guidelines or foreign standards and therefore do not necessarily correspond to the local and regional requirements;

(e) Regional cooperation has been limited to certain areas of immediate concern, while such issues as common water basins and problems related to shared water sources have not received the necessary level and degree of attention. The call for the formation of a regional water resources body has not been effectively answered.

In the light of the discussions in previous sections, a number of observations in the form of recommendations may be tentatively made:

(a) Water quality must feature prominently in any water policy and plans at the national and regional levels;

(b) Water quality assessment strategies must be formulated and effectively enacted at the national level and should include regional components to reflect the commonality of many of the problems;

(c) Integrated water legislation should include water conservation and water quality matters dealt with in accordance with the requirements of national and regional sustainable development;

(d) Water quality standards should be made in the light of internationally acknowledged guidelines, and in congruence with the national needs of the various socio-economic sectors and their sustained development;

(e) Regional cooperation on water resources should consider the problem of water quality in the region among its first priorities, and ESCWA should assist in drawing up a <u>regional plan of action on water resources</u> that will include:

(i) An information network on water quality issues;

(ii) Cooperation in formulating water quality standards, possibly through the production of guidelines specially designed to correspond to the water situation and needs of the countries and of the region as a whole;

(iii) Training programmes to upgrade personnel working in the water sector and in matters of water quality control in particular;

(iv) Model legislation for water quality control to be used as guides in the formulation of national laws and regulations;

(v) A model water management system to assist Governments in the region in the establishment of more effective water institutions;

(vi) A regional strategy for water quality assessment, including water quality monitoring, benefiting from the experience of the Global Environment Monitoring System (GEMS).

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Annex I

WHO - WATER QUALITY GUIDELINES

- Issued as submitted.

GUIDELINES FOR BACTERIOLOGICAL QUALITY OF DRINKING WATER

Bacteriological quality of drinking-water[a]

Organisms	Guideline value
All water intended for drinking	
E. coli or thermotolerant coliform bacteria[b,c]	Must not be detectable in any 100-ml sample
Treated water entering the distribution system	
E. coli or thermotolerant coliform bacteria[b]	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample
Treated water in the distribution system	
E. coli or thermotolerant coliform bacteria[b]	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample. In the case of large supplies, where sufficient samples are examined, must not be present in 95% of samples taken throughout any 12-month period.

a Immediate investigative action must be taken if either *E. coli* or total coliform bacteria are detected. The minimum action in the case of total coliform bacteria is repeat sampling; if these bacteria are detected in the repeat sample, the cause must be determined by immediate further investigation.

b Although *E. coli* is the more precise indicator of faecal pollution, the count of thermotolerant coliform bacteria is an acceptable alternative. If necessary, proper confirmatory tests must be carried out. Total coliform bacteria are not acceptable indicators of the sanitary quality of rural water supplies, particularly in tropical areas where many bacteria of no sanitary significance occur in almost all untreated supplies.

c It is recognized that, in the great majority of rural water supplies in developing countries, faecal contamination is widespread. Under these conditions, the national surveillance agency should set medium-term targets for the progressive improvement of water supplies, as recommended in Volume 3 of *Guidelines for drinking-water quality*.

GUIDELINES FOR CHEMICALS OF HEALTH SIGNIFICANCE IN DRINKING WATER

A. Inorganic constituents

	Guideline value (mg/litre)	Remarks
antimony	0.005 (P)[a]	
arsenic	0.01[b](P)	For excess skin cancer risk of 6×10^{-4}
barium	0.7	
beryllium		NAD[c]
boron	0.3	
cadmium	0.003	
chromium	0.05(P)	
copper	2(P)	ATO[d]
cyanide	0.07	
fluoride	1.5	Climatic conditions, volume of water consumed, and intake from other sources should be considered when setting national standards.
lead	0.01	It is recognized that not all water will meet the guideline value immediately; meanwhile, all other recommended measures to reduce the total exposure to lead should be implemented.
manganese	0.5(P)	ATO
mercury (total)	0.001	
molybdenum	0.07	
nickel	0.02	
nitrate (as NO_3^-)	50	The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1
nitrite (as NO_2^-)	3(P)	
selenium	0.01	
uranium		NAD

B. Organic constituents

	Guideline value (μg/litre)	Remarks
Chlorinated alkanes		
carbon tetrachloride	2	
dichloromethene	20	
1,1-dichloroethene		NAD
1,2-dichloroethene	30^b	for excess risk of 10^{-5}
1,1,1-trichloroethene	2000(P)	
Chlorinated ethenes		
vinyl chloride	5^b	for excess risk of 10^{-5}
1,1-dichloroethene	30	
1,2-dichloroethene	50	
trichloroethene	70(P)	
tetrachloroethene	40	
Aromatic hydrocarbons		
benzene	10^b	for excess risk of 10^{-5}
toluene	700	ATO
xylenes	500	ATO
ethylbenzene	300	ATO
styrene	20	ATO
benzo[a]pyrene	0.7^b	for excess risk of 10^{-5}
Chlorinated benzenes		
monochlorobenzene	300	ATO
1,2-dichlorobenzene	1000	ATO
1,3-dichlorobenzene		NAD
1,4-dichlorobenzene	300	ATO
trichlorobenzenes (total)	20	ATO
Miscellaneous		
di(2-ethylhexyl)adipate	80	
di(2-ethylhexyl)phthalate	8	
acrylamide	0.5^b	for excess risk of 10^{-5}
epichlorohydrin	0.4(P)	
hexachlorobutadiene	0.6	
edetic acid (EDTA)	200(P)	
nitrilotriacetic acid	200	
dialkyltins		NAD
tributyltin oxide	2	

C. Pesticides

	Guideline value (μg/litre)	Remarks
alachlor	20[b]	for excess risk of 10^{-5}
aldicarb	10	
aldrin/dieldrin	0.03	
atrazine	2	
bentazone	30	
carbofuran	5	
chlordane	0.2	
chlorotoluron	30	
DDT	2	
1,2-dibromo-3-chloropropane	1[b]	for excess risk of 10^{-5}
2,4-D	30	
1,2-dichloropropane	20(P)	
1,3-dichloropropane		NAD
1,3-dichloropropane	20[b]	for excess risk of 10^{-5}
ethylene dibromide		NAD
heptachlor and heptachlor epoxide	0.03	
hexachlorobenzene	1[b]	for excess risk of 10^{-5}
isoproturon	9	
lindane	2	
MCPA	2	
methoxychlor	20	
metolachlor	10	
molinate	6	
pendimethalin	20	
pentachlorophenol	9(P)	
permethrin	20	
propanil	20	
pyridate	100	
simazine	2	
trifluralin	20	
chlorophenoxy herbicides other than 2,4-D and MCPA		
2,4-DB	90	
dichlorprop	100	
fenoprop	9	
MCPB		NAD
mecoprop	10	
2,4,5-T	9	

D. Disinfectants and disinfectant by-products

Disinfectants	Guideline value (mg/litre)	Remarks
monochloramine	3	
di-and trichloramine		NAD
chlorine	5	ATO. For effective disinfection there should be a residual concentration of free chlorine of ≥0.5 mg/litre after at least 30 minutes contact time at pH <8.0
chlorine dioxide		A guideline value has not been established because of the rapid breakdown of chlorine dioxide and because the chlorite guideline value is adequately protective for potential toxicity from chlorine dioxide
iodine		NAD

Disinfectant by-products	Guideline value (μg/litre)	Remarks
bromate	25[b] (P)	for 7×10^{-5} excess risk
chlorate		NAD
chlorite	200 (P)	
chlorophenols		
2-chlorophenol		NAD
2,4-dichlorophenol		NAD
2,4,6-trichlorophenol	200[b]	for excess risk of 10^{-5}, ATO
formaldehyde	900	
MX		NAD
trihalomethanes		The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1
bromoform	100	
dibromochloromethane	100	
bromodichloromethane	60[b]	for excess risk of 10^{-5}
chloroform	200[b]	for excess risk of 10^{-5}
chlorinated acetic acids		
monochloroacetic acid		NAD
dichloroacetic acid	50 (P)	
trichloroacetic acid	100 (P)	

Guidelines for Chemicals (*continued*)

Disinfectant by-products	Guideline value (μg/litre)	Remarks
chloral hydrate (trichloroacetaldehyde)	10(P)	
chloroacetone		NAD
halogenated acetonitriles		
dichloroacetonitrile	90 (P)	
dibromoacetonitrile	100 (P)	
bromochloroacetonitrile		NAD
trichloroacetonitrile	1 (P)	
cyanogen chloride (as CN)	70	
chloropicrin		NAD

a (P) - Provisional guideline value. This term is used for constituents for which there is some evidence of a potential hazard but where the available information on health effects is limited; or where an uncertainty factor greater than 1000 has been used in the derivation of the tolerable daily intake (TDI). Provisional guideline values are also recommended: (1) for substances for which the calculated guideline value would be below the practical quantification level, or below the level that can be achieved through practical treatment methods; or (2) where disinfection is likely to result in the guideline value being exceeded.

b For substances that are considered to be carcinogenic, the guideline value is the concentration in drinking-water associated with an excess lifetime cancer risk of 10^{-5} (one additional cancer per 100,000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years). Concentrations associated with estimated excess lifetime cancer risks of 10^{-4} and 10^{-6} can be calculated by multiplying and dividing, respectively, the guideline value by 10.

In cases in which the concentration associated with an excess lifetime cancer risk of 10^{-5} is not feasible as a result of inadequate analytical or treatment technology, a provisional guideline value is recommended at a practicable level and the estimated associated excess lifetime cancer risk presented.

It should be emphasized that the guideline values for carcinogenic substances have been computed from hypothetical mathematical models that cannot be verified experimentally and that the values should be interpreted differently that TDI-based values because of the lack of precision of the models. At best, these values must be regarded as rough estimates of cancer risk. However, the models used are conservative and probably err on the side of caution. Moderate short-term exposure to levels exceeding the guideline value for carcinogens does not significantly affect the risk.

c NAD - No adequate data to permit recommendation of a health-based guideline value.

d ATO - Concentrations of the substance at or below the health-based guideline value may affect the appearance, taste, or odour of the water.

GUIDELINES FOR SUBSTANCES AND PARAMETERS IN DRINKING WATER THAT MAY GIVE RISE TO COMPLAINTS FOR CONSUMERS

	Levels likely to give rise to consumer complaints[a]	Reasons for consumer complaints
Physical parameters		
colour	15 TCU[b]	appearance
taste and odour	--	should be acceptable
temperature	--	should be acceptable
turbidity	5 NTU[c]	appearance; for effective terminal disinfection, median turbidity ≤1NTU, single sample ≤5NTU
Inorganic constituents		
aluminium	0.2 mg/l	depositions, discoloration
ammonia	1.5 mg/l	odour and taste
chloride	250 mg/l	taste, corrosion
copper	1 mg/l	staining of laundry and sanitary ware (health-based provisional guideline value 2 mg/litre)
hardness	--	high hardness: scale deposition, scum formation low hardness: possible corrosion
hydrogen sulfide	0.05 mg/l	odour and taste
iron	0.3 mg/l	staining of laundry and sanitary ware
manganese	0.1 mg/l	staining of laundry and sanitary ware (health-based provisional guideline value 0.5 mg/litre).
dissolved oxygen	--	indirect effects
pH	--	low pH: corrosion high pH: taste, soapy feel preferably <8.0 for effective disinfection with chlorine
sodium	200 mg/l	taste
sulfate	250 mg/l	taste, corrosion
total dissolved solids	1000 mg/l	taste
zinc	3 mg/l	appearance, taste
Organic constituents		
toluene	24-170 μg/l	odour, taste (health-based guideline value 700 μg/l)
xylene	20-1800 μg/l	odour, taste (health-based guideline value 500 μg/l)

	Levels likely to give rise to consumer complaints[a]	Reasons for consumer complaints
ethylbenzene	2-200 μg/l	odour, taste (health-based guideline value 300 μg/l)
styrene	4-2600 μg/l	odour, taste (health-based guideline value 20 μg/l)
monochlorobenzene	10-120 μg/l	odour, taste (health-based guideline value 300 μg/l)
1,2-dichlorobenzene	1-10 μg/l	odour, taste (health-based guideline value 1000 μg/l)
1,4-dichlorobenzene	0.3-30 μg/l	odour, taste (health-based guideline value 300 μg/l)
trichlorobenzenes (total)	5-50 μg/l	odour, taste (health-based guideline value 20 μg/l)
synthetic detergents	--	foaming, taste, odour
Disinfectants and disinfectant by-products		
chlorine	600-1000 μg/l	taste and odour (health-based guideline value 5 μg/l)
chlorophenols		
2-chlorophenol	0.1-10 μg/l	taste, odour
2,4-dichlorophenol	0.3-40 μg/l	taste, odour
2,4,6-trichlorophenol	2-300 μg/l	taste, odour (health-based guideline value 200 μg/l)

a The levels indicated are not precise numbers. Problems may occur at lower or higher values according to local circumstances. A range of taste and odour threshold concentrations is given for organic constituents.

b TCU, time colour unit.

c NTU, nephelometric turbidity unit.

GUIDELINES FOR RADIO-ACTIVE CONSTITUENTS IN DRINKING WATER

	Screening value (Bq/litre)	Remarks
gross alpha activity	0.1	If a screening value is exceeded, more detailed radionuclide analysis is necessary. Higher values do not necessarily imply that the water is unsuitable for human consumption
gross beta activity	1	

Annex II

WATER QUALITY STANDARDS
AND GUIDELINES
IN SELECTED ESCWA COUNTRIES

(Egypt, Jordan, Oman, Syrian Arab Republic, United Arab Emirates)

وزارة الصحة
<u>وكيل الوزارة للشؤون الوقائية</u>

EGYPTIAN DRINKING WATER STANDARD: ISSUED ON 11 MARCH 1995

المعايير والمواصفات الواجب توافرها في المياه الصالحة للشرب
والإستخدام المنزلي التي أقرتها اللجنة العليا للمياه
بتاريخ ١٩٩٥/٢/٢٦

<u>أولاً: الخواص الطبيعية</u>

الخاصية	الحد الأقصى المسموح به
اللون	٢٠-٣٠ كحد أقصى بمقياس الكوبالت بلاتين
الطعم	مقبول
الرائحة	معدومة
العكارة	٥ وحدات جاكسون أو ما يعادلها للمياه المرشحة ١٠ وحدات جاكسون أو ما يعادلها للمياه الجوفية والخليط
الرقم الأيدروجيني	٩ر٢-٦ر٥

<u>ثانياً: مواد غير عضوية لها تأثير على الإستساغة والإستخدامات المنزلية</u>

الخاصية	الحد الأقصى المسموح به
الأملاح الذائبة عند ١٢٠° م	١٢٠٠ ملليجرام/لتر
الحديد Fe	٠ر٣ ملليجرام/لتر للمياه المرشحة ١ر٠ ملليجرام/لتر للمياه الجوفية والخليط
المنجنيز Mn	٠ر١ ملليجرام/لتر للمياه المرشحة ٠ر٥ ملليجرام/لتر للمياه الجوفية والخليط
النحاس Cu	١ر٠ ملليجرام/لتر
الزنك Zn	٥ر٠ ملليجرام/لتر
العسر الكلي As Ca Co	٥٠٠ ملليجرام/لتر
الكالسيوم Ca	٢٠٠ ملليجرام/لتر

الخاصية	الحد الأقصى المسموح به
الماغنسيوم Mg	١٥٠ ملليجرام/لتر
الكبريتات So_4	٤٠٠ ملليجرام/لتر
الكلوريدات Cl	٥٠٠ ملليجرام/لتر
الصوديوم Na	٢٠٠ ملليجرام/لتر
الألومنيوم Al	٢ر٠ ملليجرام/لتر
التوازن الكلي	+ ١ر٠ -

ثالثاً: المواد الكيميائية ذات التأثير على الصحة العامة

(أ) المواد الغير عضوية

الخاصية	الحد الأقصى المسموح به
الرصاص Pb	٥٠ر٠ ملليجرام/لتر
الزرنيخ As	٥٠ر٠ ملليجرام/لتر
السيانيد Cn	٥٠ر٠ ملليجرام/لتر
الكادميوم Cd	٠٠٥ر٠ ملليجرام/لتر
السيلينيوم Se	٠١ر٠ ملليجرام/لتر
الزئبق Hg	٠٠١ر٠ ملليجرام/لتر
الكروميوم Cr	٠٥ر٠ ملليجرام/لتر
النترات As (N)	١٠ ملليجرام/لتر
النيتريت As (N)	٠٠٥ر٠ ملليجرام/لتر
الفلوريدات	٨ر٠ ملليجرام/لتر

(ب) المواد العضوية

(١) المبيدات

المبيدات	الحد الأقصى المسموح به ميكرو جرام/لتر
Alchlor الكلور	٢٠
Aldicarb الديكارب	١٠
Aldrin/dialdrin الدرين داى الدرين	٠٣ر٠
Atrazine إترازين	٢
Bentazon بنتازون	٣٠
Carbofuran كاربوفيوران	٥
Chlordane كلوردان	٢ر٠
Chlortofuron كلوروتوفيرون	٣٠
D. D. T. د. د. ت	٢
١ر٢ داى برومو كلوروبروبان ٢ر١ Dibromo chloropropane ٢ر١	١
٢ر٤ د D ٤ر٢	٣٠
١ر٢ داى كلوروبروبان Dichloropropane ٢ر١	٢٠
١ر٣ داى كلوروبروبان Dichloropropane ٣ر١	٢٠
Hexachlorobenzene هكسا كلورو بنزين	١
Isoproturon أيزو برتيرون	٩
Lindane لندان	٢
MCPA (Chlorophenoxy) أم س بى أيه كلوروفينوكسى	٢
Methoxychlor مينوكس كلور	٢٠
Metolachlor ميتولا كلور	١٠
Molinate مولينات	٦
Pentachlorophenol بنديمثالين	٢٠
Pentachlorophenol بنتاكلوروفينول	٩
Permethrin بيرميثرين	٢٠
Propanil بروبانيل	٢٠
Simazine سيمازين	٢
Trifluralin تراى فيلورالين	٢٠

مبيدات الحشائش كلوروفينوكسيد غير ٢ر٤ داند ام س بي ايه

Chlorophenoxy herbicides other than ٢ر٤ dand MCPA

٢ر٤ د.ب DB ٢ر٤	٩٠
داى كلور بروب 2,4 Dichloroprop	١٠٠
فينوبروب Fenoprop	٩
ميكوبروب Mecprop	١٠
٢ر٤ر٥ تى T 2,4,5	٩

(٢) <u>مواد عضوية أخرى</u>

ثلاثي بيوتيل أكسيد القصدير Tributalyltin Oxide	٢
فينول Phenol	٢

Disinfectants and disinfectant by-products المطهرات ونواتجها

أحادي كلورامين Monochloramine	٣
ثنائي وثلاثي كلورامين Di and trichlormine	٥
برومات Bromate	٢٥
كلورايت Chlorite	٢٠٠
٢ر٤ر٦ تراى كلوروفينول ٦ر٤ر٢ Trichlorophonal	٢٠٠
تراى هالو ميثان Trihalomethanes	١٠٠

Chlorinated Acetic acids أحماض الخليك المكلورة

داى كلورو استيك Dichloro acetic acid	٥٠
تراى كلورو استيك اسيد Trichloro acetic acid	١٠٠
تراى كلورو اسيتالدهيد Trichloro acetaldhyde	١٠

Halogenated acetonitriles الأسيتوثيرلات المهلجنة

ثنائي كلورو استينوميتريل Dichloro acetomitrile	٩٠
ثنائي برومو استينوميتريل Dibromo acetonitrile	١٠٠
ثلاثي كلورو استينوميتريل Trichloro acetonitrile	١
كلوريد السيانوجين Cyanogen Chloride	٧٠

Chlorinated Alkanes الكانات مكلورة

رابع كلوريد الكربون Carbon tetrachloride	٢
داى كلورو ميثان Dichloromethane	٢٠
١ر٢ داى كلورو ايثان ١ر٢ dichloroethane	٣٠
١ر١ر١ تراى كلورو ايثان ١ر١ر١ trichloroethane	٢٠٠

Cholorinated Ethanes مركبات الايثان المكلورة

كلوريد الفينيل Vinyl chloride	٥
١ر١ داى كلوروايثان ١ر٢ Dichloroethane	٣٠
٢ر١ داى كلوروايثان ١ر٢ Dichloroethane	٥٠
تراى كلوروايثان Trichloroethane	٧٠
رباعي كلوروايثان Tetrachloroethane	٤٠
الهيدروكربونات الكلية فيما عدا البنزين	١٠٠
فصورة تولوين (Total Hydrocarbons as Toluene)	١٠
بنزين Benzene	
بنزوبيرين Benzo (a) pyrine	٧ر٠

Chlorinated Benzenes البنزينات المكلورة

أحادى كلورو البنزين Monochlorobenzene	٣٠٠
١ر٢ داى كلورو البنزين dichlorobenzene	١٠٠٠
١ر٤ داى كلورو بنزين dichlorobenzene	٣٠٠
تراى كلوروبنزين Trichlorobenzene	٢٠
ثنائي (ايثيل هكسيل) أديبات Di (٢-Ethyl hexyl) adipate	٨٠
ثنائي (أيثيل هكسيل) فثلات Di (٢-Ethyl hexyl) phthalate	٨
أكريلاميد Acrylamide	٥ر٠
أيبير كلورو هيدران Epichlorohydrin	٤ر٠
هكسا كلورو بيوتاديين Hexachlorohybutadiene	٦ر٠
اديتيك اسيد Edetic acid (EDTA)	٢٠٠
نيترلو استيك اسيد Nitrilotriacetie	٢٠٠

رابعا: المعايير الميكروبيولوجية

(أ) العدد الكلي للبكتيريا

بطريقة الصب بالأطباق Poured plate method.

(١) عند درجة ٣٧ م لمدة ٢٤ ساعة لا يزيد عن ٥٠ خلية/ ١ سم٣.

(٢) عند درجة ٢٢ م لمدة ٤٨ ساعة لا يزيد عن ٥٠ خلية/ ١ سم٣.

(ب) أدلة التلوث

(١) بكتيريا القولون الكلية Total Coliform يجب أن تكون ٩٥ في المائة من العينات التي يتم فحصها خلال العام خالية تماماً من بكتيريا القولون Total Coliform في ١٠٠ سم٣ من العينة.

كما يجب أن لا تحتوي أي عينة من العينات على أكثر من ٣ خلية/ ١٠٠ سم٣ على أن لا يتكرر ذلك في عينتان متتاليتان من نفس المصدر.

(٢) بكتيريا القولون البرازية (باسيل القولون النمونجي).

يجب أن تكون جميع العينات خالية من باسيل القولون النمونجي.

(٣) البكتيريا السبحية البرازية.

يجب أن تكون جميع العينات خالية من الميكروب السبحي البرازي.

(ج) الفحص البيولوجي

عند فحص المياه ميكروسكوبيا يجب أن تكون خالية تماماً من البروتوزوا وجميع أطوار الديدان المسببة للأمراض والطحالب الزرقاء المخضرة Bluegreen algae.

خامسا: المواد المشعة

مشتقات من فصيلة ألفا (α) ١ر٠ ميكروكيودي/لتر.
مشتقات من فصيلة بيتا (β) ٠ر١ ميكروكيودي/لتر.

تنفيذ المعايير

أولا: يبدأ الإلتزام الفوري من تاريخ صدور القرار الخاص بالمواصفات فيما يختص بالخواص الطبيعية المواد الغير عضوية ذات التأثير على الإستساغة والإستخدامات المنزلية وعلى أن يتم إجراؤها روتينياً لجميع عينات المياه.

ثانيا: يبدأ الإلتزام الفوري من تاريخ صدور القرار الخاص بالمواصفات بالمعايير الميكروبيولوجية والبيولوجية روتينيا لجميع العينات.

ثالثا: بالنسبة للمواد الكيميائية ذات التأثير على الصحة العامة.

(أ) المواد الغير عضوية

يبدأ الإلتزام الفوري بالمعايير الخاصة بالمواد الغير عضوية ذات التأثير على الصحة العامة على أن يتم إجراؤها مرة كل شهر على الأقل لكل مورد مائي.

(ب) المواد العضوية

(١) يبدأ الإلتزام بالمعايير الخاصة بمركبات الميثان المكلورة بعد عام ميلادي من تاريخ إقرار المعايير.

(٢) يبدأ الإلتزام بالمعايير الخاصة بالمبيدات والمركبات العضوية الأخرى بعد عامين من إقرار المعايير على أن تلتزم جميع الجهات بإجرائها لعينات ممثلة لجميع مصادر المياه مرة كل ستة شهور على الأقل.

رابعا: يبدأ الإلتزام الفوري بالمعايير الخاصة بالمواد المشعة لعينات ممثلة لجميع مصادر المياه وتتولى إجراءها الهيئة العامة للطاقة الذرية وإخطار وزارة الصحة بأنها في حدود الأمان النووي وذلك لحين توفر إمكانيات القياس بمعامل وزارة الصحة.

خامسا: يجب على الهيئات المنتجة للمياه عند التعاقد على إنشاء محطات مياه جديدة مراعاة التزام التصميم الهندسي وطرق المعالجة بالوصول إلى المياه المنتجة مطابقة للمواصفات وتجهيز معاملها بالإمكانيات اللازمة لطرق قياسها. ورفع كفاءة محطات تنقية مياه الشرب الحالية مرحلياً للوصول بإنتاجها إلى المواصفات.

سادسا: تجرى جميع الفحوص والتحاليل طبقاً لطرق القياس الواردة في كتاب:
Standard Methods for the Examination of water and waste water (A.P.H.A and E.P.A.) last edition.

وتتولى الإدارة المركزية للمعامل بوزارة الصحة اختيار أنسب الطرق الواردة في الكتاب المذكور وطبعها وتوزيعها على جميع معامل المحافظات وتدريب العاملين بها وتوفير إمكانيات تطبيقها من أجهزة ومعدات وكيماويات مع تطبيق الرقابة على القياسات على مستوى الجمهورية لتقييم أداء المعامل المختلفة Quality Control.

المملكة الأردنية الهاشمية

م ق أ/٢٨٦/ ١٩٩٠ م

المواصفات القياسية الأردنيـــــة
رقــم (٢٨٦)

JORDANIAN STANDARD

No. 286

مياه الشــــــــرب
Drinking Water

وزارة الصناعة والتجـــــارة
مديرية المواصفات والمقاييس

عمّـــــان

MINISTRY OF INDUSTRY AND TRADE

AMMAN

٣-٣ الخصائص الطبيعية (الفيزيائية): Physical Properties:

ان لا تزيد الخصائص الطبيعية (الفيزيائية) على الحدود المبينة أدناه في الجدول ١.

الجدول ١

الخاصية	الحد المسموح به	أقصى ما يمكن السماح به في حالة تعذر وجود مورد أفضل
الطعم	مستساغ لأغلب المستهلكين	
الرائحة	مستساغة لأغلب المستهلكين	
اللون	١٠ وحدات مقدرة بمقياس الكوبلت البلاتيني	١٥ وحدة
العكارة	وحدة واحدة مقدرة بجهاز الشمعة لجاكسون او ما يعادلها	٥ وحدات
الاس الهيدروجيني pH	ان لا يقل عن ٦ر٥ ولا يزيد على ٩	
درجة الحرارة	يفضل ان تكون ما بين ٨-٢٥ س	

٣-٤ الخصائص الكيميائية: Chemical Properties:

٣-٤-١ المواد السامة:

يجب أن لا تزيد نسب المواد السامة التالية في المياه على الحدود المبينة أدناه في الجدول ٢.

الجدول ٢

المـــادة	الرمـــــز	الحد الأقصى/ملغم/لتر
الرصاص	Pb	٠ر٠٥
السيلينيوم	Se	٠ر٠١
الزرنيخ	As	٠ر٠٥
الكروم الكلي	Cr	٠ر٠٥
السيانيد	CN	٠ر١
الكادميوم	Cd	٠ر٠٠٥
الزئبق	Hg	٠ر٠٠١
الانتيمون	Sb	٠ر٠١
الفضة	Ag	٠ر٠١

٣-٤-٢ المواد التي لها تأثير خاص على الصحة وصلاحية المياه:

يجب أن لا تزيد المواد ذات التأثير الصحي او الاستساغي او التي تعتبر مؤشرا للتلوث على الحدود المبينة ادناه في الجدول ٣.

الجدول ٣

المادة	الرمز	الحد المسموح به ملغم/لتر	أقصى ما يمكن السماح به في حالة تعذر وجود مورد أفضل ملغم/لتر	نوعية التأثير ضمن الحد الأقصى الواردة في هذا الجدول
الاملاح الذائبة الكلية	TDS	٥٠٠	١٥٠٠	استساغي
العسر الكلي	TH(CaCO3	١٠٠	٥٠٠	استساغي
المنظفات	ABS	٠ر٥	١ر٠	مؤثر تلوث
الالمنيوم	Al	٠ر٢	٠ر٣	استساغي
الحديد	Fe	٠ر٣	١ر٠	استساغي
المنغنيز	Mn	٠ر١	٠ر٢	استساغي
النحاس	Cu	١ر٠	١ر٥	استساغي
الخارصين	Zn	٥	١٥	استساغي
الصوديوم	Na	٢٠٠	٤٠٠	استساغي
النيكل	Ni	٠ر٠٥	٠ر١	صحي
الكلوريد	Cl	٢٠٠	٥٠٠	استساغي
الفلوريد	F	١ر٠	١ر٥	صحي
الكبريتات	SO_4	٢٠٠	٥٠٠	استساغي
النترات	NO_3	٤٥	٧٠	صحي

٣-٤-٣ المواد المشعة:

يجب أن لا تزيد المواد المشعة في المياه على الحدود الموضحة في الجدول ٤ وعند زيادتها عن هذه الحدود يلزم اجراء تحاليل بواسطة جهة متخصصة ومعتمدة لتحديد العناصر المشعة والمسببات وتأثيرها على الصحة.

الجدول ٤

المـــــادة	الحد الأقصـــــى
مشعات الفـــا	١ر٠ بيكوريل/لتر (ما عدا الرادون)
مشعات بيتـــا	١ بيكوريل/لتر

٣-٤-٤ الملوثات العضوية:

٣-٤-٤-١ يجب أن لا تزيـد نسب الملوثات العضوية في مياه الشرب على الحدود المبينة أدناه في الجدول ٥.

المـــــــادة	الحد الأقصى المسموح به ملغم/لتر
أ. المواد الكلورينية العضوية	
اندرين	٠٫٠٠٠٢
لندين	٠٫٠٠٤
ميتوكسي كلور	٠٫١
توكسافين	٠٫٠٠٥
ب. المواد العضوية الكلوروفينوكسية	
2,4 - D	٠٫١
2,4,5 - TP	٠٫٠١

٣-٤-٤-٢ ان لا تزيد نسب الملوثات العضوية الأخرى (غير المذكورة في الجدول ٥) على الحدود المسموح بها من قبل منظمة الصحة العالمية.

٤- المصطلحات الفنيـــة

١-	مشعات الفـا	Alpha emitters
٢-	مشعات بيتـا	Beta emitters
٣-	المواد الكلورينية العضوية	Clorinated hydrocarbons
٤-	المواد العضوية الكلوروفينوكسية	Clorophenoxys
٥-	2,4 - D	2,4 Dichlorophenoxy acetic acid
٦-	اندرين	Endrin
٧-	الكائنات الطليقة	Free living organisms
٨-	لنديـن	Lindane
٩-	ميتوكسي كلور	Methoxychlor
١٠-	طريقة غشاء الترشيح	Membrane filter test
١١-	طريقة تعدد الأنابيب	Multiple tube test
١٢-	توكسافين	Toxaphene
١٣-	العسر الكلي	Total hardness
١٤-	2,4-5 - TP	2,4-5 Trichlorophenoxy propionic acid

٥- المراجـــــع

١- المواصفة السعودية رقم ٤٠٩/١٩٨٤م

٢- المواصفة السورية رقم ٤٥/١٩٧٣

٣- المواصفة العمانية رقم ٨/١٩٧٨

٤- المواصفة اللبنانية رقم ٧٥/١٩٧٠

٥- المواصفة المصرية رقم ١٥٨٩/١٩٨٦

٦- دليل منظمة الصحة العالمية لنوعية مياه الشرب مجلد ١، ٢، ٣
Guidelines for Drinking Water Quality, Vol. 1,2,3

٧- مواصفات السوق الأوروبية المشتركة لعام ١٩٧٥

٨- مواصفات مياه الشرب الصادرة عن منظمة حماية البيئة الامريكية
U.S Environmental Protection Agency
Primary Drinking Water Regulation - 1986

٩- المواصفات الكندية لنوعية مياه الشرب
Canadian Drinking Water Quality Criteria

١٠- المواصفات الألمانية لمياه الشرب.

٦- الجهات التي شاركت في تعديل المواصفة(*)

١- وزارة المياه والري
٢- وزارة الزراعة
٣- وزارة الصحة/قسم صحة البيئة
٤- وزارة التموين
٥- الجامعة الأردنية/مركز بحوث المياه
٦- الجامعة الأردنية/كلية الزراعة
٧- الجامعة الأردنية/كلية الطب
٨- أمانة عمان الكبرى
٩- الجمعية العلمية الملكية

(*) هذه المواصفة تعديل للمواصفة رقم ٢٨٦ لعام ١٩٨٨.

* نسخة طبق الأصـــل*

تم اعادة طباعتها وتدقيقها في مديرية المختبرات ومراقبة النوعية

سلطة الميـــــــاه

OMANIAN STANDARD

No. 8

DRINKING WATER

MINISTRY OF COMMERCE AND INDUSTRY
DIRECTORATE GENERAL FOR SPECIFICATIONS AND MEASUREMENTS

FOREWORD

1. The draft of this Omanian Standard was drawn up by the Directorate General for Specifications and Measurements in the Ministry of Commerce and Industry.

2. The draft standard was based on:

   a) Draft Arab Standard ASMO 1/1977, Drinking water and standard methods for testing and analysis.

   b) International Standards for drinking water published by the World Health Organization (1971) and the results of tests performed on different samples of available water from different sources.

3. The draft standard has been circulated to the concerned ministries and the Ghubrah Desalination and Power Station for comments.

4. The Ministry has formed a technical committee for water from members representing the following:

   Ministry of Agriculture, Fisheries, Petroleum & Minerals
   Ministry of Health
   Ministry of Land Affairs and Municipalities
   Ministry of Electricity and Water
   Ministry of Commerce and Industry
   Ghubrah Desalination and Power Station

   This committee has reviewed the draft standard and finalized it in the light of comments received.

5. The Ministry of Commerce and Industry has adopted this standard as Omanian Standard, OS 8/1978 dated 1978-10-18.

   The Arabic text is the legal text.

DRINKING WATER

1. SCOPE

This Omanian Standard specifies the chemical and bacteriological properties of water to be used for drinking and for the preparation of food.

2. REFERENCE

OS 14-24, Methods of testing drinking water.

3. SPECIFICATIONS

3.1 Physical properties

The water shall, in general, be colourless, tasteless, odourless and free from turbidity.

3.2 Chemical properties

3.2.1 Toxic chemicals

The percentage of the contents mentioned below should not exceed the following corresponding levels:

Substance	Maximum permissible level (mg/l)
Lead	0.10
Selenium	0.01
Arsenic	0.05
Cadmium	0.01
Cyanide	0.05
Mercury	0.001

3.2.2 Chemicals that have special effects on health

The percentages of the contents mentioned below should not exceed the following corresponding levels:

Substance	Maximum permissible level (mg/l)
Fluoride	0.8
Nitrate	45

3.2.3 Chemicals that affect the suitability of water for domestic and drinking purposes

The percentages of the contents mentioned below should not exceed the following corresponding levels:

Substance	Highest desirable level (mg/l)	Maximum permissible level (mg/l)
Total dissolved solids	500	1500
Copper	0.05	1.5
Iron	0.1	1.0
Magnesium	Not more than 30mg/l if there are 250mg/l of sulphate; if there is less sulphate, magnesium up to 150mg/l may be allowed	150
Manganese	0.05	0.5
Zinc	5.0	15
Calcium	75	200
Chloride	200	600
Sulphate	200	400
Phenolic compounds (as phenols)	0.001	0.002
Total hardness	100	500
pH range	7.0 to 8.5	6.5 to 9.2

3.2.4 Minimum residual chlorine concentrations required for effective disinfection of drinking water. Treated water should contain a minimum residual chlorine of 0.2 to 0.5 mg/l.

3.3 Bacteriological properties

3.3.1 Treated water

a) No sample should contain *Escherichia coli (E. coli)* in 100 ml.

b) No sample should contain more than 10 coliform organisms in 100 ml.

c) Throughout any year, 95% of the samples examined should not contain any coliform organisms in 100 ml.

3.3.2 Untreated water

a) No sample should contain *Escherichia coli (El. coli)* in 100 ml.
b) No sample should contain more than 10 coliform organisms in 100 ml.

4. METHODS OF TEST AND ANALYSIS

See OS 14-24.

م.ق.س ١٩٧٣/٤٥

المواصفة القياسية السورية

رقم/٤٥/

SYRIAN STANDARDS

No. 45

مياه الشرب

DRINKING WATER

MINISTRY OF INDUSTRY
DAMASCUS

وزارة الصناعة
هيئة المواصفات والمقاييس العربية السورية
دمشق

م ق س ١٩٧٣/٤٥	مياه الشرب	الجمهورية العربية السورية هيئة المواصفات والمقاييس العربية السورية
UDC 543.3		
SNS 45/1973		

١- المجال

تشمل هذه المواصفة القياسية الخصائص الفيزيائية والكيميائية والسمية والجرثومية لمياه الشرب (ويقصد بها المياه الصالحة للشرب وللاستعمال في الصناعات الغذائية والحاجات المنزلية. كما تشمل طرق أخذ العينات وتكرار ودورية أخذ العينات ونوعية التحاليل ونماذج عن التقارير الخاصة بها.

٢- الخصائص الفيزيائية

١/٢ تكون مياه الشرب خالية بصفة عامة من العكر، عديمة اللون والرائحة وذات طعم مستساغ. ويسمح عند الضرورة بحدود معينة من اللون والعكر على ألا يتعديا الحدود المبينة فيما يلي:

	أقصى ما يمكن السماح به في المسموح بهحالة تعذر مورد أفضل
اللون	٥ وحدات مقدرة بمقياس الكوبالت البلاتيني ٥٠ وحدة
العكارة	٥ وحدات مقدرة بجهاز الشمعة لجاكسون ٢٥ وحدة

٢/٢ المواد المشعة

يجري تحديد المواد المشعة في مياه الشرب عند الضرورة وينبغي ألا تزيد على الحدود المبينة فيما يلي:

تاريخ النشر ١٩٧٣/٦/٢٠	وزارة الصناعة دمشق	تاريخ الاعتماد ١٩٧٣/٥/٢١

المادة	أقصى ما يمكن السماح به
مشعات ألفا	١٠-٩ ميكرو كيوري في المليلتر
مشعات بتا	١٠-٨ ميكرو كيوري في المليلتر

٣- الخصائص الكيميائية

ويقصد بها دراسة نسبة المواد الكيميائية التي توجد في الماء والناجمة عن احتوائه على بعض العناصر والأملاح، التي تؤثر على الصحة وعلى صلاحية المياه للشرب والاستعمالات الغذائية.

٣/١ يجب ألا تزيد نسبة المواد المذكورة أدناه على الحدود المبينة في الجدول التالي:

المادة	الرمز	المسموح به مغ/ل	أقصى ما يمكن السماح به في حالة تعذر مورد أفضل مغ/ل
أ- المواد التي تؤثر على الصحة وعلى صلاحية الماء للشرب والاستعمالات المنزلية			
١- مجموع الخلاصة الجافة		٥٠٠	١٥٠٠
٢- القساوة الكلية مقدرة بفحمات الكالسيوم(*)	$(CaCo_3)$	٣٠٠	٦٥٠
٣- الرقم الهدروجيني	(PH)	٧-٥ر٨ (وحدة)	٥ر٦-٢ر٩ (وحدة)
٤- الحديد	(Fe)	٣ر٠	١ر٠
٥- المنغنيز	(Mn)	١ر٠	٥ر٠
٦- النحاس	(Cu)	١	٥ر١
٧- التوتياء	(Zn)	٥	١٥
٨- المغنيزيوم	(Mg)	٥٠	١٥٠
٩- الكالسيوم	(Ca)	٧٥	٢٠٠
١٠- الكبريتات	(SO_4)	٢٠٠	٤٠٠
١١- الكلوريد	(Cl)	٢٠٠	٦٠٠
١٢- الفلوريد	(F)	٦ر٠	٥ر١
١٣- النترات	(NO_3)	١٥	٤٠
١٤- الكلور الحر للمياه المعالجة	(Cl)	٣ر٠-٥ر٠	١ في حالات الأوبئة(**)
١٥- مواد أخرى يجري فحصها عند الضرورة		-	-
ب- المواد التي تدل على التلوث			
١- الأمونياك	(NH_3)	عدم وجوده	آثار زهيدة (شرط صلاحية المياه للشرب جرثوميا)
٢- النتريت	(No_2)	عدم وجوده	عدم وجوده

(*) على أن لا يزيد مجموع المغنزيوم والكالسيوم مقدرة كفحمات على ٦٥٠ مغ/ل.
(**) يمكن زيادة المقدار حسب تعليمات وزارة الصحة.

٢/٣ تقدر نسب جميع المواد المذكورة في الفقرة ١/٣ لعينات المياه التي لم يسبق تحليلها كيميائيا وبشكل دوري، ينظم بنتيجة التحليل تقرير حسب النموذج الوارد في الملحق رقم (١) من هذه المواصفة.

ملاحظة: -١- هناك مواد كيميائية تدل على التلوث لم تذكر في الجدول المدون في الفقرة ١/٣. وهذ المواد توجد بنسب غير ثابتة في مصادر المياه المختلفة لذا فان زيادتها على النسبة السائدة الموجودة في منطقة المورد يعتبر دليلا على التلوث. ان تقدير كمية التلوث يعتمد على تقدير الزيادة التي تحدث في نسبة هذه المواد في المياه بين منطقة التحليل ومنطقة المورد. وهذه المواد هي:

١- الأمونياك الآحيني.
٢- النترات.
٣- النتروجين العضوي الكلي.
٤- مجموع المواد العضوية (الأوكسجين الكيميائي المستهلك) ويعتبر الماء نقيا جدا اذا كان الأوكسجين الكيميائي المستهلك مساويا (١) مغ/ل، ويعتبر شريبا اذا كان مقداره يتراوح بين (١-٢) مغ/ل، ويكون مشبوها بين (٢-٤) مغ/ل ورديئا اذا تجاوز ذلك.
٥- الأوكسجين الحيوي المستهلك (يجب أن يكون مساويا الصفر).
٦- الكلوريد.
٧- الفوسفات.

٤- الخصائص السمية الكيميائية

ويقصد بها معرفة تلوث المياه بالمواد السامة والفضلات الصناعية التي تحول دون استعمالها كماء شروب، وعند وجود بعضها يسمح بحدود معينة لا يجوز تجاوزها.

١/٤ يجب ألا تزيد نسبة المواد المذكورة أدناه على الحدود المبينة في الجدول التالي:

المادة	الرمز	أقصى ما يمكن السماح به مغ/ل
١- الرصاص	(Pb)	٠٫٠٥
٢- السيلينيوم	(Se)	٠٫٠١
٣- الزرنيخ	(As)	٠٫٠٥
٤- الكروم سداسي التكافؤ	(Cr)	٠٫٠٥
٥- السيانيد	(CN)	٠٫٠١
٦- المركبات الفنولية (مقدرة كفنول)		٠٫٠٠١
٧- الكادميوم	(Cd)	٠٫٠١
٨- مواد أخرى تقدر عند الضرورة		

٢/٤ ينظم بنتيجة التحليل تقرير حسب النموذج الوارد في الملحق رقم (٣).

٥- الخصائص الجرثومية

ويقصد بها التحري عن وجود جراثيم ممرضة أو غير ممرضة تؤثر على صلاحية مياه الشرب وتحدد هذه الخصائص بما يلي:

١/٥ المياه المعالجة

١/١/٥ يجب الا يزيد العدد الارجح (MPN) لعصيات الكليفورم على (١) في (١٠٠) مل مع ذكر حدود الثقة. ان هذه النتيجة خاصة بالعينة المفحوصة ولا تدل على حالة المورد الا اذا أخذت عينات دورية طوال العام. ويجب في هذه الحالة الا يزيد العدد الأرجح لعصيات الكوليفورم على (١) في (١٠٠) مل في (٩٠)٪ من العينات المأخوذة خلال العام.

٢/١/٥ ينبغي الا يزيد العدد الكلي للجراثيم في المليلتر الواحد على (١٠٠٠).

٣/١/٥ ينبغي أن تكون خالية من الطفيليات والجراثيم الممرضة.

٤/١/٥ ينبغي ألا تحتوي على عصيات الأشيريشيا (اشيريشيا-كولي).

٥/١/٥ ينبغي الا تحتوي على المكورات المعوية الغائطية.

٦/١/٥ ينبغي الا تحتوي على المطثيات الولخية (كلور ستريديوم ولشي).

٧/١/٥ تهمل نتائج التحليل الجرثومي المطبقة على النماذج غير المستوفية للشروط الفنية اللازمة المنصوص عنها في الملحق رقم (٦) من هذه المواصفة.

٢/٥ المياه غير المعالجة

١/٢/٥ يجب ألا يزيد العدد الأرجح لعصيات الكوليفورم على (١٠) في (١٠٠) مع ذكر حدود الثقة. هذه النتيجة خاصة بالعينة المفحوصة، ولا تدل على حالة المورد الا اذا أخذت عينات دورية طوال العام ويجب في هذه الحالة الا يزيد العدد الأرجح لعصيات الكليفورم على (١٠) في (١٠٠) مل في (٩٠)٪ من العينات المأخوذة خلال العام.

٢/٢/٥ تطبق على المياه غير المعالجة جميع الشروط الأخرى المنصوص عنها والمتعلقة بالمياه المعالجة أي الفقرات من (٢/١/٥) حتى (٧/١/٥).

٣/٥ التحاليل الجرثومية اللازم اجراؤها.

٥/٣/١ التحليل الجرثومي العادي

ويطبق على المياه التي سبق فحصها دوريا، ويشمل ما يلي:

٥/٣/١/١ التعداد العام للجراثيم.

٥/٣/١/٢ تحديد العدد الأرجح لعصيات الكوليفورم في (١٠٠) مل من المياه.

٥/٣/١/٣ تحديد العدد الأرجح لعصيات الاشيريشيا في (١٠٠) مل من المياه.

٥/٣/٢ التحليل الجرثومي الكامل(*)

ويطبق على المياه التي لم يسبق فحصها جرثوميا وبشكل دوري ويشمل ما يلي:

٥/٣/٢/١ التعداد العام للجراثيم.

٥/٣/٢/٢ تحديد العدد الأرجح لعصيات الكوليفورم في (١٠٠) مل من المياه.

٥/٣/٢/٣ تحديد العدد الأرجح لعصيات الاشيريشيا في (١٠٠) مل من المياه.

٥/٣/٢/٤ كشف المكورات المعوية الغائطية.

٥/٣/٢/٥ كشف المطثيات الولخية والجراثيم المرضية الأخرى.

٥/٣/٢/٦ اجراء الزرع الجرثومي المناسب عند الضرورة.

٥/٣/٣ في حالة وجود وباء ينبغي أخذ كل الاحتياطات الخاصة بالتحاليل المتعلقة بالوباء المذكور.

٥/٣/٤ ينظم تقرير التحليل الجرثومي العادي وفق النموذج الوارد في الملحق رقم (٤) وتقرير التحليل الجرثومي الكامل وفق النموذج الوارد في الملحق رقم (٥).

(*) عند تعذر وجود مختص في الجراثيم في مخابر مؤسسات المياه أو غيرها. ترسل العينات الى المخابر المختصة، كمخابر وزارة الصحة أو غيرها.

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UNBOTTLED DRINKING WATER

United Arab Emirates
UDC 663.6

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Date of Board of Directors' Approval

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Corresponding to

UNBOTTLED DRINKING WATER

1- SCOPE AND FIELD OF APPLICATION

The Gulf standard is concerned with unbottled drinking water

2- COMPLEMENTARY REFERENCES

2.1 Gulf standard to be approved by the Organization on: "Methods of Test for Drinking and Mineral Water".

2.2 Gulf standard to be approved by the Organization on: "Limits of Radiation Levels Permitted in Foodstuffs".

3- DEFINITIONS

3.1 Unbottled drinking water

Water fit for human consumption which is supplied to the consumer through the public distribution system, or the limited water supply system, or from wells, springs or any other water source from surface water sources used for drinking and complying with all the specific properties mentioned in this standard.

3.2 Public distribution system

A system for supplying the consumer with water suitable for human consumption, and includes collection, treatment, storage and distribution of drinking water from the source to the consumer.

3.3 Limited water system

A system for supplying the consumer with water suitable for human consumption and comprises less than 15 connections.

3.4 Well

A vertical hole cut into the earth for access to underground water.

3.5 Spring

A place where a natural outflow of water to the surface of the ground takes place.

3.6 Surface water

Collection of rain water in valleys or behind dams or in tanks for use in drinking.

4- CHARACTERISTICS

The following shall be met in unbottled drinking water:

4.1 Characteristics relating to quality

4.1.1 Physical characteristics

4.1.1.1 The unbottled water shall not contain any substances that would affect its colour, taste, odour or appearance. It shall be completely free from foreign substances or impurities which can be seen with the naked eye whether they are earth, sands, threads, hairs or other impurities.

4.1.1.2 The physical characteristics shall be as mentioned in Table (1):

Table (1)
Physical characteristics of unbottled drinking water

Characteristics	Unit of Measure	Maximum Permissible Level
Colour	True colour unit (Platinum cobalt meter)	15 units
Turbidity	Unit with turbiditemeter	5 units
Taste	-	Acceptable
Odour	-	Acceptable

4.1.2 Chemical characteristics

Characteristics of chemical components related to quality of unbottled drinking water shall be as mentioned in Table (2):

Table (2)
Chemical characteristics related to quality of unbottled drinking water

Component	Unit	Maximum Permissible Level
pH	-	6.5-8.5
Total dissolved solids	p.p.m.	100-1000
Magnesium	"	150*
Calcium	"	200*
Total hardness (as calcium carbonate)	"	500
Sodium	"	200
Sulfate	"	400
Chloride	"	250
Aluminum	"	0.2
Iron	"	0.3
Copper	"	1

Table (2) ***(continued)***

Component	Unit	Maximum Permissible Level
Zinc	"	5
Manganese	"	0.1
Ionic detergents	"	0.2
Electrical conductivity at 25°C	ms/cm	160-1600

* Magnesium content shall not exceed 30 ppm if 250 ppm of sulfates are present, and shall not exceed 150 ppm if sulfates content is less.

** Calcium and magnesium content shall be observed, so as not to exceed the limits of total hardness content.

4.2 Characteristics of inorganic constituents which have an effect on health:

The content of Inorganic constituents which have an effect on health shall be according to Table (3):

Table (3)
Ratio of inorganic constituents which have an effect on health in unbottled drinking water

Constituent	Maximum Limit (ppm)	Constituent	Maximum Limit (ppm)
Arsenic	0.05	Total	
Cadmium	0.005	Chromium	0.05
Cyanide	0.05	Nitrate (as nitrogen gas)	10.0
Mercury	0.001	Fluoride	0.6-1.7*
Selenium	0.01	Lead	0.05
		Nitrite (No_3)	Less than one ppm

* The fluoride concentration in unbottled drinking water according to daily atmospheric temperature is determined as follows:

$$\text{Fluoride concentrate} = \frac{0.34}{D}$$

Where:

$$D = 0.038 + [0.0062 \times (\text{daily atmospheric temperature in °C} \times \frac{9}{5} + 32)]$$

4.3 Characteristics of organic constituents which have an effect on health:
The ratio of organic constituents which have an effect on the health shall be according to Table (4):

Table (4)
Ratio of organic constituents which have an effect on health in unbottled drinking water

	Constituent	Maximum Permissible Level (mg/l)
4.3.1	Pesticide:	
	Aldrin and dieldrin	0.03
	Lindane	3.0
	Methoxychlor	30.0
	2,4-D	100.0
	Chlordane	0.3
	Heptachlor and heptachlor epoxide	0.1
	Hexachlorobenzene	0.01
	DDT	1.0
4.3.2	Polynuclear aromatic hydrocarbons:	
	Sum	0.2
	Benzopyrene	0.01
4.3.3	Organic halogen compounds:	
	Sum	250.0
	Chloroform	30.0
4.3.4	Benzene	10.0
4.3.5	Phenolic compounds:	
	Pentachlorophenol	10.0
	2,4,6-trichlorophenol	0.1
4.3.6	1,2 dichloroethane	10.0
	1,2 dichloroethene	0.3

4.4 Free residual chlorine

4.4.1 Free residual chlorine concentration in treated unbottled drinking water shall be sufficient to kill all microbes therein, provided that the free residual chlorine concentration in this water when it reaches the consumer shall range between 0.2 ppm and 0.5 ppm.

4.4.2 Concentration of chlorine shall be increased in cases of epidemic or in special circumstances according to the instructions of the Ministries of Health or the concerned authorities.

4.5 When the water is treated with ozone, ultra-violet rays or by any other means, this treatment shall be sufficient to kill all microbes and the treated water shall conform to the microbiological characteristics of treated water mentioned in 4.7.2.1.

4.6 Biological characteristics

Unbottled drinking water shall be completely free from algae, moulds, parasites, and insects, their eggs, larvae, vesicles, insect parts and the protozoan including ameba.

4.7 Microbiological characteristics

4.7.1 Unbottled drinking water shall be completely free from pathogenic and faecal microbes and viruses which may be hazardous to public health.

4.7.2 Piped water supply system

4.7.2.1 Treated water entering the distribution system

a. It shall be free from coliform bacteria in any 100 ml of the examined sample.

b. It shall be free from faecal coliform bacteria in any 100 ml of the examined sample.

4.7.2.2. Untreated water entering the distribution system

a. It shall be free from coliform bacteria in any 100 ml of the examined sample in 98% of the samples examined throughout the year, in the case of large supplies when sufficient samples are examined.

b. It shall be free from faecal coliform bacteria in any 100 ml of the examined sample.

c. Coliform bacteria shall not exceed 3 colonies/100 ml in an occasional sample, but not in two consecutive samples.

4.7.3 Unpiped water supplies

4.7.3.1 Coliform bacteria shall not exceed 10 colonies/100 ml in the examined sample provided that it does not occur repeatedly, if occurrence is frequent and if sanitary protection cannot be improved, an alternative source must be found if possible.

4.7.3.2 It shall be free from faecal coliform bacteria in any 100 ml.

4.8 Radioactive characteristics of the examined sample

Radioactive characteristics for unbottled drinking water shall conform to the Gulf standard to be approved by the Organization on: "Limits of Radiation Levels Permitted in Foodstuffs".

Annex III

FAO - GUIDELINES FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION

GUIDELINES FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION

Potential Irrigation Problem		Units	Degree of Restriction on Use: None	Slight to Moderate	Severe
Salinity *(affects crop water availability)*[2]					
EC_W		dS/m	< 0.7	0.7 -3.0	> 3.0
	(or)				
TDS		mg/l	< 450	450 - 2000	> 2000
Infiltration *(Affects infiltration rate of water into the soil. Evaluate using EC_W and SAR together)*[3]					
SAR	= 0 - 3 and EC_W	=	> 0.7	0.7 - 0.2	< 0.2
	= 3 - 6	=	> 1.2	1.2 - 0.3	< 0.3
	= 6 - 12	=	> 1.9	1.9 - 0.5	< 0.5
	= 12 - 20	=	> 2.9	2.9 - 1.3	< 1.3
	= 20 - 40	=	> 5.0	5.0 - 2.9	< 2.9
Specific Ion Toxicity *(Affects sensitive crops)*					
Sodium (Na)[4]					
	surface irrigation	SAR	< 3	3 - 9	> 9
	sprinkler irrigation	me/l	< 3	> 3	
Chloride (Cl)[4]					
	surface irrigation	me/l	< 4	4 - 10	> 10
	sprinkler irrigation	me/l	< 3	> 3	
Boron (B)[5]		mg/l	< 0.7	0.7 - 3.0	> 3.0
Miscellaneous Effects *(affects susceptible crops)*					
Nitrogen (NO_3 - N)[6]		mg/l	< 5	5 - 30	> 30
Bicarbonate (HCO_3) *(overhead sprinkling only)*		me/l	< 1.5	1.5 - 8.5	> 8.5
pH				Normal Range 6.5 -8.4	

1 Adapted from University of California Committee of Consultants 1974.

2 ECw means electrical conductivity, a measure of the water salinity, reported in deciSiemens per metre at 25°C (dS/m) or in units millimhos per centimetre (mmho/cm). Both are equivalent. TDS means total dissolved solids, reported in milligrams per litre (mg/1).

3 SAR means sodium adsorption ratio. SAR is sometimes reported by the symbol RNa. See Figure 1 for the SAR calculation procedure. At a given SAR, infiltration rate increases as water salinity increases. Evaluate the potential infiltration problem by SAR as modified by ECw. Adapted from Rhoades 1977, and Oster and Schroer 1979.

4 For surface irrigation, most tree crops and woody plants are sensitive to sodium and chloride; use the values shown. Most annual crops are not sensitive; use the salinity tolerance tables (Tables 4 and 5). For chloride tolerance of selected fruit crops, see Table 14. With overhead sprinkler irrigation and low humidity (< 30 percent), sodium and chloride may be absorbed through the leaves of sensitive crops. For crop sensitivity to absorption, see Tables 18, 19 and 20.

5 For boron tolerances, see Tables 16 and 17.

6 NO_3 -N means nitrate nitrogen reported in terms of elemental nitrogen (NH_4 -N and Organic- N should be included when wastewater is being tested).

Assumptions in the Guidelines

The water quality guidelines in Table 1 are intended to cover the wide range of conditions encountered in irrigated agriculture. Several basic assumptions have been used to define their range of usability. If the water is used under greatly different conditions, the guidelines may need to be adjusted. Wide deviations from the assumptions might result in wrong judgements on the usability of a particular water supply, especially if it is a borderline case. Where sufficient experience, field trials, research or observations are available, the guidelines may be modified to fit local conditions more closely.

The basic assumptions in the guidelines are:

Yield Potential: Full production capability of all crops, without the use of special practices, is assumed when the guidelines indicate no restrictions on use. A "restriction on use" indicates that there may be a limitation in choice of crop, or special management may be needed to maintain full production capability. A "restriction on use" does not indicate that the water is unsuitable for use.

Site Conditions: Soil texture ranges from sandy-loam to clay-loam with good internal drainage. The climate is semi-arid to arid and rainfall is low. Rainfall does not play a significant role in meeting crop water demand or leaching requirement. (In a monsoon climate or areas where precipitation is high for part or all of the year, the guideline restrictions are too severe. Under the higher rainfall situations, infiltrated water from rainfall is effective in meeting all or part of the leaching requirement.) Drainage is assumed to be good, with no uncontrolled shallow water table present within 2 metres of the surface.

Methods and Timing of Irrigations: Normal surface or sprinkler irrigation methods are used. Water is applied infrequently, as needed, and the crop utilizes a considerable portion of the available stored soil-water (50 percent or more) before the next irrigation. At least 15 percent of the applied water percolates below the root zone (leaching fraction [LF] $\geq$ 15 percent). The guidelines are too restrictive for specialized irrigation methods, such as localized drip irrigation, which results in near daily or frequent irrigations, but are applicable for subsurface irrigation if surface applied leaching satisfies the leaching requirements.

Water Uptake by Crops: Different crops have different water uptake patterns, but all take water from wherever it is most readily available within the rooting depth. On average about 40 percent is assumed to be taken from the upper quarter of the rooting depth, 30 percent from the second quarter, 20 percent from the third quarter, and 10 percent from the lowest quarter. Each irrigation leaches the upper root zone and maintains it at a relatively low salinity. Salinity increases with depth and is greatest in the lower part of the root zone. The average salinity of the soil-water is three times that of the applied water and is representative of the average root zone salinity to which the crop responds. These conditions result from a leaching fraction of 15-20 percent and irrigations that are timed to keep the crop adequately watered at all times.

Salts leached from the upper root zone accumulate to some extent in the lower part but a salt balance is achieved as salts are moved below the root zone by sufficient leaching. The higher salinity in the lower root zone becomes less important if adequate moisture is maintained in the upper, "more active" part of the root zone and long-term leaching is accomplished.

Restriction on Use: The "Restriction on Use" shown in Table 1 is divided into three degrees of severity: none, slight to moderate, and severe. The divisions are somewhat arbitrary since change occurs gradually and there is no clearcut breaking point. A change of 10 to 20 percent above or below a guideline value has little significance if considered in proper perspective with other factors affecting yield. Field studies, research trials and observations have led to these divisions, but management skill of the water user can alter them. Values shown are applicable under normal field conditions prevailing in most irrigated areas in the arid and semi-arid regions of the world.

LABORATORY DETERMINATIONS NEEDED TO EVALUATE COMMON IRRIGATION WATER QUALITY PROBLEMS

Water parameter	Symbol	Unit[1]	Usual range in irrigation water	
SALINITY				
Salt Content				
Electrical Conductivity	EC_w	dS/m	0 - 3	dS/m
(or)				
Total Dissolved Solids	TDS	mg/l	0 - 2000	mg/l
Cations and Anions				
Calcium	Ca^{++}	me/l	0 - 20	me/l
Magnesium	Mg^{++}	me/l	0 - 5	me/l
Sodium	Na^{+}	me/l	0 - 40	me/l
Carbonate	CO_3^{--}	me/l	0 - .1	me/l
Bicarbonate	HCO_3^{-}	me/l	0 - 10	me/l
Chloride	Cl^{-}	me/l	0 - 30	me/l
Sulphate	SO_4^{--}	me/l	0 - 20	me/l
NUTRIENTS[2]				
Nitrate-Nitrogen	NO_3-N	mg/l	0 - 10	mg/l
Ammonium-Nitrogen	NH_4-N	mg/l	0 - 5	mg/l
Phosphate-Phosphorus	PO_4-P	mg/l	0 - 2	mg/l
Potassium	K^{+}	mg/l	0 - 2	mg/l
MISCELLANEOUS				
Boron	B	mg/l	0 - 2	mg/l
Acid/Basicity	pH	1-14	6.0 - 8.5	
Sodium Adsorption Ratio[3]	SAR	$(me/l)^{1,2}$	0 - 15	

[1] dS/m = deciSiemen/metre in S.I. units (equivalent to 1 mmho/cm = 1 millimmho/centimetre)

mg/l = milligram per litre ≃ parts per million (ppm).

me/l = milliequivalent per litre (mg/l ÷ equivalent weight = me/l); in SI units, 1 me/l = 1 millimol/litre adjusted for electron charge.

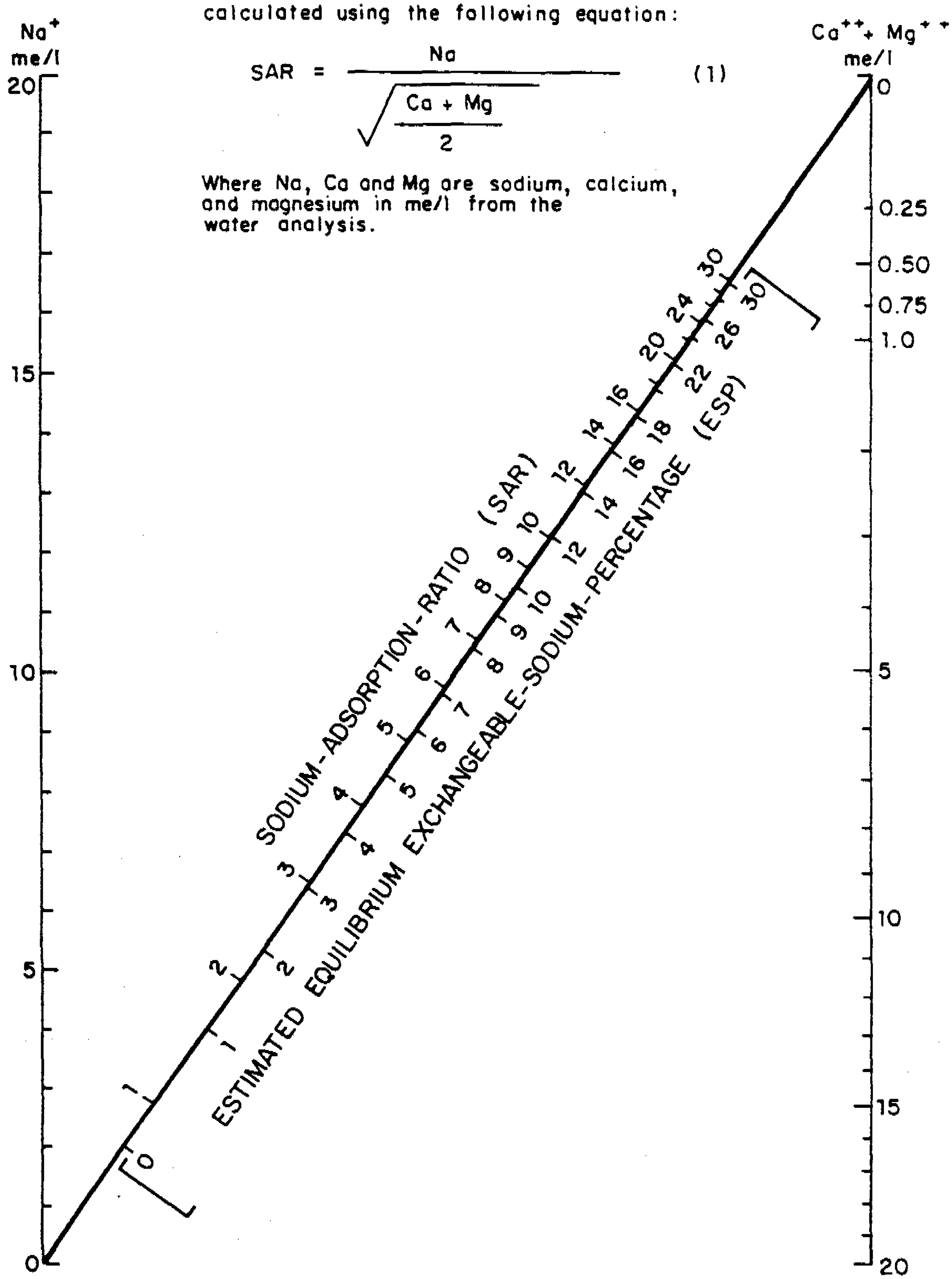
[2] NO_3-N means the laboratory will analyse for NO_3 but will report the NO_3 in terms of chemically equivalent nitrogen. Similarly, for NH_4-N, the laboratory will analyse for NH_4 but report in terms of chemically equivalent elemental nitrogen. The total nitrogen available to the plant will be the sum of the equivalent elemental nitrogen. The same reporting method is used for phosphorus.

[3] SAR is calculated from the Na, Ca and Mg reported in me/l (see Figure 1).

The Sodium Adsorption Ratio (SAR) can also be calculated using the following equation:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}} \qquad (1)$$

Where Na, Ca and Mg are sodium, calcium, and magnesium in me/l from the water analysis.



Nomogram for determining the SAR value of irrigation water and for estimating the corresponding ESP value of a soil that is at equilibrium with the water (Richards 1954)

GLOSSARY OF TECHNICAL TERMS

Anion	A negatively charged ion in an electrolyte solution, attracted to the anode under the influence of electric potential.
Anionic membrane	A semi-permeable membrane which allows passage of anions but is impermeable to cations.
Aquifer	A porous, water-bearing geologic formation. Generally restricted to materials capable of yielding an appreciable supply of water.
Biodegradable	Capable of being oxidized to carbon dioxide, water, and mineral substances by the action of bacteria.
Calcination	The process of altering the chemical composition of a substance by application of heat at high temperatures.
Capacity building	The process of building organizations, human resources and the legal and regulatory framework needed for effective and efficient water resources management.
Catchment area	The area from which rainfall flows into a river, reservoir, etc.
Cation	The ion in an electrolyte which carries the positive charge and which migrates toward the cathode under the influence of a potential difference.
Cationic membrane	A semi-permeable membrane which allows passage of cations, but is impermeable to anion.
Colloids	Finely divided solids which will not settle in water, but may be removed by coagulation or biochemical action or membrane filtration; they are intermediate between true solutions and suspensions.
Comprehensive water resources management	Water resources planning, development and control that incorporates physical, social, economic and environmental inter-dependencies.
Conventional treatment	Treatment of wastewater by means which have become well established and which are now in widespread use.
Cost recovery	Fee structures that cover the cost of providing the service or investment.
De-centralization	The distribution of responsibilities for decision making and operations to lower levels of government, community organizations, the private sector, and non-governmental organizations (NGOs).

Delft Declaration	Declaration of Capacity Building, agreed at the UNDP Symposium "A Strategy for Water Resources Capacity Building", held in Delft, the Netherlands, June 1991.
Demand management	The use of price, quantitative restrictions and other devices to limit the demand for water.
Direct cycle reuse	Reuse of wastewater directly from the effluent treatment plants after purification to required quality.
Dublin Statement	The Dublin Statement on Water and Sustainable Development, adopted at the International Conference on Water and the Environment (ICWE).
Ecosystem	A complex system formed by the interaction of a community of organisms with its environment.
Helsinki Rules	Helsinki rules on the Uses of the Waters of International Rivers, agreed in 1966, and since extended to include groundwater.
HRD	Human resources development, i.e., the enhancement of knowledge and skills, plus the creation of optimum development conditions to use these.
ICWE	International Conference on Water and the Environment, attended by over 500 participants from over 100 countries and over 80 international governmental organizations and NGOs, and held in Dublin, Ireland, 26-31 January 1992. It resulted in the Dublin Statement.
IHE	International Institute for Hydraulic and Environmental Engineering.
Indirect cycle reuse	Reuse of wastewater that has been discharged to surface or ground water after treatment. Reuse occurs when the water is withdrawn for use, the wastewater having undergone natural purification process and having been somewhat diluted.
Institutions	Organizational arrangements and the legal and regulatory framework - the 'enabling environment' - in which organizations operate. More broadly, institutions include entities, processes and linkages between individual entities.
Pathogenic organisms (bacteria and viruses)	Organism which may cause disease in a host organism by their parasitic growth.
pH	The reciprocal of the logarithm of the hydrogen ion concentration. The concentration is the weight of hydrogen ions, in grams, per litre of solution. Neutral water, for example, has a pH value of 7 and a hydrogen-ion concentration of 10-7.
Plant nutrient	A substance usually of mineral origin which is necessary for plant growth.
Policy	A declared intention and course of action adopted by government, party, etc., for the achievement of a goal.

Programme	A definite plan of intended procedure.
Project	A scheme or undertaking.
Return flow	Any flow of water that returns to a stream channel after diversion for irrigation or other purposes.
Reverse osmosis	The reversal of the normal direction of diffusion of the solvent in osmosis by the imposition of a pressure head.
Riparian State	A State through or along which a portion of a river flows or a lake lies.
River basin	A geographical area (catchment area) determined by the watershed limits of a water system, including surface and underground water, flowing into a common terminus.
Semi-permeable membrane	A barrier, usually thin, that permits passage of particles up to a certain size or of special nature.
Sensitivity analysis	Assessment of the response of some factors, as a result of changes in others.
Sewage	Liquid refuse or waste matter carried off by sewers.
Sewerage	The removal and disposal of sewage and surface water by sewer systems.
Stakeholder	An organization or individual that is concerned with or has an interest in water resources and that would be affected by decisions about water resources management.
Strategy	A set of chosen short-, medium- and long-term actions to support the achievement of development goals and to implement water-related policies.
Watercourse	A system of surface and underground waters that constitute, by virtue of their physical relationship, a unitary whole and that flow into a common terminus.
Watershed	The line separating waters flowing into different rivers, basins or seas. Often used to mean catchment area or river basin.
Wetlands	Areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water less than six metres deep at low tide.