

Yemen s Water Resources And Treated Wastewater*

Introduction:

Water is the main core in the socio-economic development in the country. Yemen as other countries in the region is situated in arid and semi-arid zone, which is known for its scarce rainfall and high evaporation. Pronounced differences in the topography affect climatic conditions and limit agriculture to areas of rainfall and groundwater availability such as the western mountains, basin areas, and *wadi* beds. Rains only in spring & summer seasons.

The population is around 18.2 Million, 76% of them living in the rural areas, 24% is in the urban areas, and the annual population growth is scored 3.7% (statistics year book, 2000). About 20% of the population in the rural areas has access to the safe drinking water, and has no access to adequate sanitation facility. In urban areas 45% of the population has access to safe drinking water, while only 20% of the urban areas. There are only 9 treatment stations are functioning in nine Governorates;

I- Water Resources

A-Renewable Water Resources:

The annual precipitation averages 500-800mm at western high lands, and less than 50mm at coasts of red sea and Gulf of Aden.

Surface water is considered to be an important source for irrigation in Yemen. This source of water is less affected by drought and other natural and geographical factors. High runoff speed and heavy rainfall cause deep *wadis* and form several water basins. Topographic patterns control the flow of rainwater.

Surface water in Yemen is estimated to be about 1,500 Mm³/year. Several dams and dikes were built on many main *wadis* for the purpose of directing spate waters into man made spate irrigation systems, which irrigate around 120,000-150,000 hectares.

Groundwater resources are vital for Yemen's agriculture. For their recharge they depends mainly on spate running water and rainfall. Runoffs and springs in catchment's areas are the main sources of groundwater recharges. The estimated of the groundwater is around 1000MCM, made the total of the renewable water resources the sum 2.5 MCM, while the total demand is estimated by 3,400MCM with 900MCM deficit, which is covered from the deep aquifers. (NWRA-report 2000).

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B- Non-conventional Water:

There is either brackish water (high saline) in some regions, which is being used for rock cutting industry mainly in high lands, as well as for irrigating some tolerant crops mainly in costal plains. These cases are found in some ground water aquifers but it is not intensively investigated and exploited.

Waste Water Quantity:

The total no of the treatment stations in Yemen are 9 stations in function, the total actual flow of the treated wastewater is around 92,000m³ per day, and around 33.5MCM per year. This amount produced through 9 functional treatment stations, which its details shown in the table No (1).

Table (1)^

Station	Design Capacity (M ³ /d)	Type of Treatment	Actual flow (M ³ /d)	Cost of Treatment U.S.\$ /m ³	Disposal Method
Sana'a	50,000	Activated Sludge	20,000	0.25	Irrigation*
Ta'aiz	17,000	W.S.P./Biological Ponds	17,000	0.03	Irrigation*
Al Hudeidah	18,000	W.S.P. Biological Ponds	18,000	0.03	Sea+ Irr.
Aden	15,000	W.S.P. Biological Ponds	15,000	0.03	Sea+ Irr.
Ibb	7,000	Activated Sludge	7,000	0.25	Irrigation*
Dhamar	10,000	W.S.P. Biological Ponds	6,000	0.03	Irrigation*
Hajja	5,000	Trickling Filter	1,150	NA	Irrigation*
Mukalla	8,000	W.S.P. Biological Ponds	6,000	0.025	Sea
Rada'a	2,800	W.S.P. Biological Ponds	1,500	0.025	Irrigation*
Total	132,800		91,650		

*Uncontrolled Irrigation.

^(Adopted from, data provided from Ministry of Electricity & water, 2000)

The 33MCM produced is considered approx.69% of the total design capacity for the 9 stations under operation. It is expected to reach the production at design capacity in the next five years.(Ministry of Electricity & Water, 2000).

There are 3 treatment stations (stabilization Ponds) in Aden (new), Yarim, and Amran under construction with design capacity of 60,000, 3,500, 6,000M³/day consequently. These stations will be functioning in the year 2002. There are also, 3 stations under planning phase in Beit Al-faqih, Bagel and Zabid.

Wastewater Quality:

The quality of the outflow varies from area to another, while it is very good quality in Hajjah, it is very bad in Taiz, depending on the method of treatment as well as the capacity of the station and the operational circumstances.

The quality of treated waste water is detailed in the table No (2), where the analytical data made available in each station.

Wastewater Discharge Quality

Parameter	Sana'a	Aden	Dhamar	Hudiedah	Yemen Standards
BOD (mg/l)	24	N.A	102	106	150
COD (mg/l)	103	N.A	189	348	500
TDS (mg/l)	1852	1695	700	3110	450-3000
SS (mg/l)	28	N.A	580	128	50
EC micr-mohs/cm	2850	2840	920	5186	700-4000
FC /100ml	12,000	80,000	110,000	1366	<1000

II- Water Resources Development and Uses

A- Water Resources Development:

Due to the water scarcity in Yemen, the state relies in its plans, policies, strategies, and actions to work in different directions to develop and conserve the water resources in the country.

- 1- **Rainfall water harvesting:** through constructing the dams, and water constructions such as diversion weirs, water concrete tanks and canals, The purpose of these structures to provide surface water for multi-usages. The final aim is to reduce pumping the ground water from the deep aquifers, as well as to recharge the shallow aquifers from the reserved water in the dam reservoirs. There are around 650 water-harvesting structures in the country.
- 2- **Improving the Irrigation efficiency:** through introducing improved irrigation techniques either localized systems or improved surface irrigation systems. The irrigated area by improved system is around 10,000Ha, round the country.
- 3- **Extensive investigations for groundwater:** the purpose is to trace promising aquifers to cover the drinking water requirements for the increasing population.

B- Water Resources Use:

Agricultural sector is the dominant user for the water resources, while the domestic and industry sector are using 7-8% of the water resources, agriculture is using around 93% of the water resources (see Table No 3, below). The cultivated area of Yemen was estimated in 2000 to be about 1,143,441 hectares of which 45% is depending on rainfall (514,550 hectares), while 55% (601,461 hectares) is irrigated by : groundwater (40% = 457,375 ha.) or surface water from seasonal water floods (Spate Irrigation,15% = 217,549 ha.). Of the latter 63,985 hectares are irrigated by springs.

The main rainfall areas are mountainous. Here terraces are built on which barley, sorghum, maize, some pulses are grown. In some areas, particularly during dry seasons, supplementary irrigation is needed. Mostly surface and groundwater are used here.

Many farmers are pumping groundwater from wells by using diesel pumps or electric pumps. Such wells can have different production volumes from one basin to another. Their production is between 5 liter/sec to 50 liter/sec. There are 52,000 to 55,000 active wells have been estimated in Yemen. These wells have a relatively low production. The volume of the water that is pumped every year from these wells is about 1.5 BCM. There are about 150 water well drilling rigs in use in Yemen that are owned by individuals or companies, who generally do not have any drilling permits, despite governmental legislation limiting the drilling of wells. Recently National Water Resources Authority started a program of registrations for the water wells drilling companies.

Another development improving the availability of water in farming areas is the rapidly spreading use of plastic and galvanized pipes. In the period between 1997 and 2000 about 15,000 hectares of farmland have been connected to wells by this means. It is expected that this figure will rise by 8000 ha a year until 2010 (*Ministry of Agriculture, Statistical Yearbook 2000*).

There are also estimates that there will be an improvement for using the available water at a 35% to 60% higher efficiency rate in irrigated areas, which will result in a reduction of water consumption (*Ministry of Agriculture, Statistical Yearbook 2000*).

Table 3: Use of Water for a Period of 30 Years (1990-2010) in Different Water Use Categories (Million cu. Meters/Year)

Water Use	1990	2000	2010*
Agriculture	2,600	3145	3,328
Domestic	168	210	552
Industrial & Mining	31	45	90
Total	2,799	3,400	3,970

*Estimates.

Source: Adapted from: TNO Institute of Applied Geo-science Report, (1995).

It is clear that, there is big gap between the size of the use and the size of the renewable resources. The deficit is covered from the underground aquifers. The annual water share is not exceeding 140m³ per capita, which is below the water poverty line.

C-Treated wastewater reuse

There are two types of reuse in agriculture:

Controlled Irrigation: is practiced by the government projects in the Ministry of Agriculture and Irrigation, to build the green belts mainly in the coastal plain cities (Aden, Hodeidah), and for sand dunes fixation or desertification control, in the affected areas at coastal plains.

Non-controlled Irrigation: (commonly in the high lands and Wadis), and is practiced by the farmers themselves to grow corn, fodders in some areas (in Taiz area), and to grow restricted and non-restricted crops, like vegetables (Tomato, Carrot), and fruits (in Sana'a area).

III- Policies, Strategies and programs:

All water related strategies, policies, and laws in Yemen are calling to consider the treated wastewater as water resources, and should be utilized in proper safe manner. The existing policies, strategies, and laws as follow:

- Water Resources Policy and strategy.(2000-1999)
- Irrigation Water policy.(2001)
- Watershed Policy.(2000)
- Agricultural sector reform policy.(2000)
- Environment protection Law.(1995)
- Yemeni Water Quality Standards.(2000)
- Draft water law (in the parliament for ratification-2001)
- Draft wastewater reuse strategy.(under developing-2001)
- Urban Water Sector Policy.(1997)

Most of the above strategies & policies support to implement some wastewater management activities in the form of targeted projects and programs.

IV- Water Resources Institutions:

There are in Yemen different institutions dealing with water and wastewater. These institutions have by their mandate related responsibilities.

1- National Water Resources Authority (NWRA):

The Establishment of the National Water Resources Authority (NWRA) was set up with the presidential decree N° 154-1996. NWRA is responsible for water resource planning and monitoring, legislation and public awareness. It should be mentioned that NWRA is under capacity building stage where it has only three branches in the governorates, beside it's headquarter in Sana'a.

2- Ministry of Agriculture & Irrigation (MAI):

Before establishing NWRA, the Ministry was responsible for the water resources planning & development, till 1996, when it was restructured to be responsible for irrigation activities, planning, development, implementation and monitoring. MAI is functioning through its offices in the all governorates. In addition to some specialized authorities in the fields of agricultural researches, agricultural and rural development regional authorities, cooperatives, companies, and projects. The MAI is also responsible to provide the technical guidance and extension services for the farmers.

In addition to some activities related to the reuse of treated waste water, such as:

- Project of Watershed Management and Wastewater Re-use in Pre-Urban Areas of Yemen (WWPU)-(1998-2001), which is supported financially by the Dutch Govt. and technically by FAO. The project worked to use the treated wastewater in forestations. This project, among others a national wastewater re-use strategy to be adopted in Yemen.

- Land & Water Conservation Project (LWCP 1995-2001): which is financed by World Bank, and technically supported by FAO, prepared some studies and technical reports on the wastewater issues. It was planned to have some experiments for the recharging the treated wastewater in coastal plain areas to prevent the sea intrusion. But this activity is planned to start in the next phase of the project during (2003-2008).

3- Ministry of Electricity & Water (MEW):

The MEW is responsible for water supply & sanitation services in the cities only. Within the ministry, Central Corporation for water supply and sanitation was established. During the last years this corporation has been decentralized in some major cities. The ministry and its corporations are responsible for planning and developing water supply & sanitation services, which include implementing sewage systems, and constructing and operating the treatment plants. The ministry now is working to draft strategy for sanitation.

4- Ministry of Local Administration (MLA):

The MLA is responsible for water supply & sanitation in the rural areas, (districts, and villages level).

5- Ministry of Tourism & Environment (MTE):

The MTE, through Environment Protection Authority (EPA), is responsible to the issues related to applying the Environment Protection Law of 1995. This Law is stipulated an Environmental Impact Assessment (EIA) for projects which are by its nature a source of environmental pollution (Environment Protection Law, Article 36). EPA is responsible for observing and measuring the pollution of the natural resources in the country.

6- Ministry of public works & urban Planning (MPWUP):

The ministry is responsible for observing and monitoring the drinking water purification stations.

V- Issues related to the current practices:

Generally the treatment stations are built in two different areas:

-Coastal Plain areas: where most of the treated wastewater is discharged to the sea, while the treatment is only secondary treatment.

-High land areas: where the landownership comes to be as main problem in the large scale of treatment plants. And the effluents are discharged to the Wadis where the farmers are dealing with this water without any training or extension services.

There is now new study conducted by a consultant hired by the German Bank for Financial Cooperation who is financing the water supply and sanitation services in parts of the country. The study prepared terms of reference for the feasibility study of the reuse. The feasibility will be conducted in the areas of Ibb, Hajjah where the

treatment stations are functioning, and in the areas of Aden, Amran and Yarim, where the treatment stations are under completion phase. It is expected the study to be initiated by the September 2002.

Problems:

There are several problems starting from the water supply system to the treatment plants, then to the main users (Mainly the Farmers):

- Odor and insects are prevailing in some treatment stations.
- Low quality treated wastewater produced from the treatment station.
- Farmers have no experience to deal with low quality water in agriculture.
- Public health impact, and skin diseases among farmers.
- Soil salinity problems.
- Plant disease occurred in the plants irrigated with treated wastewater.
- Animals are suffering from some diseases due to the direct touches with wastewater.

VI- Institutional Problems:

- High water loses in the water supply network,
- Ineffective management,
- Poor maintenance,
- Low tariffs,
- Un-trained staff.
- Frequent Power cut off in some treatment stations.
- Disposal of produced sludge and farmers unwillingness to use it
- Hospitals, industrial factories, and car washing/lubricant change services centers, are connected to the public sewage work with no primary treatment.
- There are no integrated plans for the reuse of the treated wastewater, due to the low quality of the effluent.
- Poor coordination among the concerned agencies.
- There is no application for Environment Impact Assessment during the establishment of some treatment plants (EIA)

VII- Recommendations:

Institutional and legal aspects have a particular importance in the utilization of treated effluents and sludge. Therefore it is of high significance to clarify the legal framework and to take account on the specific conditions. Quality standards of the treated effluent and sludge have to be defined/applied as well as regulation and control procedures for monitoring.

Field management practices

The management of water, soil, crop and operational procedures plays an important role in the successful re-use of treated effluent and sludge. Managing Strategies such as Water Management Strategies (appropriate irrigation method, leaching, drainage, irrigation scheduling, etc.), Land and Soil Management Strategies, Crop Management and Cultural Practices (crop restriction, placement of seed, etc.) have to be developed.

Social and economic framework

Transformation of institutional and legal arrangements for overall operation concept of re-use schemes has to be provided (e.g. Wadi Association) including the elaboration of financing schemes.