CONSERVATION OF DOMESTIC WATER USE FOR JEDDAH CITY USING SIMULATION MODEL

S. Awadalla* and M. AbdulRazzak**

*Soil and Water Institute and **UNESCO Office Cairo

Abstract

Jeddah is one of the principal cities of Western Region of Saudi Arabia. The population of Jeddah increased along with a concurrent expansion of the city. Rapid growth has reflected the increasing scale of the city. About 1,475,990 people resided in Jeddah as of year 1990, and the population is increased to 2.5 millions in the year of 2000. This increase in urban population will require additional water supplies, where it is limited. Therefore, one of the most primary strategies of water conservation measures should be applied to fulfill the future water demand.

In this study the main aim was to develop a strategy to minimize water demand by using simulation model which has been developed by Institute of Water Resources-Municipal and Industrial Needs (IWR-MAIN).

The study includes 9 classifications for Jeddah city according to the distribution of Jeddah municipalities. Each municipality zone has been divided into smaller areas depending on the included services such as water pipe connection, sewage, and other services which important as required data for the model applications. In this study five major conservation measures were used (price policy, Public education, Leak detection, Moderate plumbing code, and Advance plumbing code). Also, evaluation of existing water supplies for the year 2000.

The estimation of water consumption as a total of Jeddah city found as 0.270 cubic meter per day in the year of 1990 and 0.290 cubic meters per day in the year 2000. It has been found by using the above conservation methods, 13.2% of water consumption can be saved at the year of 1990 while 16.5% at the 2000. The study can assist the water distribution planner and decision maker for water conservation measures and to suggest a water future plan.

1. Introduction

One of the principal cities of the western region of Saudi Arabia is Jeddah city which is located on the eastern shore of the Red Sea of the Arabian Peninsula. The population of Jeddah increased substantially after 1970 along with a concurrent expansion of the city's area. This increase in urban population will require additional water supplies that have been met mainly from sea desalination. The

water demand for Jeddah in 1990 was estimated at 207 million cubic meters per year and the demand for the year 2000 reach 329 million cubic meters per year. To assess and forecast water demand of Jeddah a simulation model used (IWR-MAIN). The model was developed by Davis et al. (1987) for the U.S. Army Corps Engineers Institute of Water Resources. Hanks (1970) in his study to estimate the residential water demand in Boulder, Colorado, In an attempt to state the effect of flat rate price structure versus metered on the domestic and sprinkling water demand concluded that the water used for both categories was lowered due to the use of the charge. Baumann (1974, 1975, 1990) highlighted that there are numerous forces and factors influencing urban water supply planning, management and conservation programs. Danielson (1979) concluded that household size explains water demand more than any other variable, in his study of analysis of residential demand for water. Williams et al. (1986) in their study of the demand for urban water by consumer class concluded that demand is relatively price elastic for residential and commercial water consumption. Albraithen (1993) in his study of municipal water demand management in the Riyadh city of Saudi Arabia highlighted that the public education and water loss from the distribution system are the most important to be implemented. Davis et al. (1978) presented results of a study related to perception and attitude of individuals in the Washington State Water policy, by means of a mailed questionnaire. The respondents were most supportive of proposals to; 1) institute voluntary programs for water conservation, and 20 impose negative incentives on users who waste water. The findings also suggested that efforts to promote conservation may be more effective if associations of water uses are encouraged to participate more actively in such efforts. Griffith (1978) carried out a study which emphasized the need for cooperation of agencies and planners for planning future water droughts through rationing. The study summarized the response of metropolitan water district of Southern California to the drought of 1975-1977. The district's system of cut backs and reallocation was outlined. By use of industry conservation, 10 % saving July-August of 1977 was accomplished. The study concluded that the drought brought close cooperation and coordination between agencies and institutions concerned with water resources in Southern California. The public had been awakened to the problems of future water supply and costs. Development analysis association (1978) presented a preliminary application of water demand modeling for various levels of water conservation and reuse for Jeddah-Makkah-Taif area. It was theoretically shown that the aggressive water conservation and reuse efforts. Rubinstein et al. (1984) pointed out that as water becomes relatively more scare and as the cost of developing new sources of water increases, projects designed to reduce the quantities of water consumed become attractive alternatives to supply augmentation projects. Kempe (1990) indicated that water conservation is one of the best options for water facing water shortages. Sorman and AbdulRazzak (1994) studied the possibility of urban water conservation of conducting field surveys in the major cities of the western region of Saudi Arabia. They concluded that the actual field study and evaluation of survey data took more time and manpower than originally anticipated due to the extensive nature of survey questionnaire. Further analysis is being made to identify relevant model input parameters.

2. Study Area

The city of Jeddah is located on the Red Sea coast of Saudi Arabia. To the east of the city a break in outlying foothills of Saudi Arabia massif provide access to Makkah, Climatically, Jeddah lies in the arid zone between the mild climate of the Mediterranean Basin, and the, monsoon climate of the Indian Ocean. In general, the most frequent wind direction in Jeddah is from the west to northwest. Furthermore, the Red sea coastal area experiences winds from the easterly direction less than 3 percent of the time.

Rainfall data recorded at the station in Jeddah during 17 years suggests that the annual rainfall in the northern section of the city ranges from 20 to 100 millimeters, occurring mainly during the winter season.

Water supply in the city comes from two sources, wade Fatima and Wade Khulais. For supplying additional water to the city desalination plants were constructed to supply 207 million cubic meters of water per year. Further, in the year 2000 the water supply has increases to 325 million cubic meters. The total population in Jeddah in the 1980 was 916,000 while in the year 2000 has reached 2.561,560.

3. Model Application and Results Analysis

The IWR-MAIN system is a sophisticated and flexible computer program designed for estimating and forecasting municipal water requirements. Water requirements can be estimated separately for the residential, commercial, industrial, and public sectors of urban areas.

The Model is applied for nine districts of Jeddah city according to the system of sewage and water pipe connection. Data collection is carried out through questionnaire forms which were circulated by personal interviews at various districts of Jeddah. The idea was to get the basic information and factors which were related to water consumption and conservation measures. The collection information on the total number at 307 interviewed questionnaires was then transferred into data base forms for analysis. Surveys are categorized under nine municipalities with more than 40 districts.

For running the model, several maps, reports and published documents are also processed and put under various pieces of information such as employment and population numbers in the base year, number, type and condition of building in various floors, etc.

The municipalities are subdivided according to the existing condition of the following categories: 1- government water supply with sewage collection, meter-sewered (MS) 2- government water supply without sewage collection, meter-

unsewered (MU). 3- No water supply flat rate with partial sewage collection (FRS). 4- No water supply with no sewage available Five type of water conservation measures were selected to applicable for Jeddah city and cumulative water consumption values are calculated through the model for 1990 and 2000. The selected restricted measures are: 1-Public education program (PE) 2- Pricing policy PP). 3- Leak detection and repair (LD) 4- Moderate plumbing code (MP) 4- Advanced plumbing code (AP). The conserved water in percentage due to the major conservative measures is determined so that the results are presented in table1, Fig.1 and 2.

The total water consumption per capita is determined to be .207 cubic meters per day in 1990 and the 0,209 cubic meters per day in the year 2000. But using the five conservation items in the model the conserved water is found to be at least 13.2 saved in the base year 1990 with the population of 1,475,560. In the year 2000, even more water 16.5 %.

4. Conclusions

It can be seen that a variety of conservation methodologies can be implemented to achieve various conservation goals ranging from actual reduction in the amount of water used, to monetary savings and extension of the life of municipal facilities and water resources. These methods can be accomplished on individual, community or municipal basis. Demand reduction through education is potentially one of the most effective methods of conservation as it creates conservation consciousness which will result in increased awareness and cooperation on the part of the user, since the responsibility for water conservation rests primarily with the user. Education programs are most recommended when geared to elementary and secondary school level. Children who grow up with the concept of water conservation will likely be conscious adults. To boost public education programs the users must be given an accurate picture of how water is being used, in what quantities, and how different conservation techniques will affect the overall availability of water. Through the program, handbooks on water conserving techniques for the household have been distributed. Water saving workshops directed at apartment mangers have been conducted. Film and slide programs, as well as television and newspaper announcements, have been employed. Also, consumer oriented domestic water conservation programs should be aimed at the use of water efficient equipment at home, especially in the bathroom. There are a variety of water saving devices which can be used in new construction. These are: low flow shower heads, low-volume flush toilets, air-assisted flush toilets and shower heads, pressure regulators and water efficient appliances. Retrofit programs in the existing housing include: toilet dams, toilet displacement bags and bottles, shower flow restrictors and faucet aerators.

Table 1 Unrestricted and restricted water use in Jeddah city for the year 1990 and the year 2000 (Unit 1000 cubic meter/day)

Municipality	Year	Unrestricted water use	Cumulative restricted water use									
			PE	%	pp	%	LD	%	Mp	%	AP	%
Alazizziyah	1990	32.34	31.47	2.7	30.9	4.2	30.8	4.8	30.5	5.7	30.4	6.1
	2000	92.32	87.8	4.9	86.0	6.8	84.3	8.6	80.3	12.9	78.6	14.8
Albalad	1990	53.50	50.8	4.9	49.8	6.8	48.3	9.6	44.7	16.4	43.2	19.2
	2000	98.20	93.3	4.9	91.5	6.8	88.7	9.6	82.0	16.4	79.3	19.2
Aljamea	1990	48.9	46.6	4.9	45.5	6.8	44.3	9.4	41.2	15.6	40.0	18.2
	2000	87.00	82.7	4.9	81.0	6.8	78.8	9.4	73.4	15.6	71.1	18.2
Aljanoob	1990	11.77	11.2	4.8	10.9	6.7	10.8	8.1	10.5	8.0	10.3	12.2
	2000	25.35	24.12	4.8	23.6	6.9	23.3	6.7	22.6	11.0	22.3	12.2
Almattar	1990	32.80	31.9	2.7	31.4	4.2	29.6	5.0	30.6	6.5	30-.5	7.0
	2000	72.10	68.5	4.9	67.1	6.8	65.2	9.5	60.5	16.0	58.6	18.7
Alsharafiyah	1990	44.20	42.0	4.9	41.1	6.8	40.0	9.5	37.1	16.0	35.9	18.8
	2000	83.20	79.1	4.8	77.5	6.8	75.2	9.5	69.8	16.0	67.5	18.8
Alshatea	1990	24.60	23.9	2.8	23.5	4.2	23.3	4.9	23.1	5.9	23.0	6.2
	2000	46.00	43.7	4.9	42.8	6.8	41.9	8.7	39.9	13.2	39.0	15.1
Jeddah Aljaddidah	1990	38.90	37.9	2.7	37.2	4.2	37.0	4.8	36.9	5.7	36.6	5.8
	2000	74.30	70.6	4.9	69.2	6.8	68.0	8.4	65.3	12.0	64.1	13.6
Qasser Khuzam	1990	58.40	55.5	4.9	54.4	6.7	52.9	9.4	49.1	15.9	47.5	18.6
	2000	117.00	111.2	4.9	10.9.1	6.7	106.	9.4	98.3	15.9	95.2	18.6
Total	1990	345.41	331.9	3.9	325.7	5.7	319.5	7.5	305.3	11.36	299.8	13.2
	2000	695.47	661.3	4.9	648.1	6.8	632.8	9.0	596.0	14.3	580.7	16.5

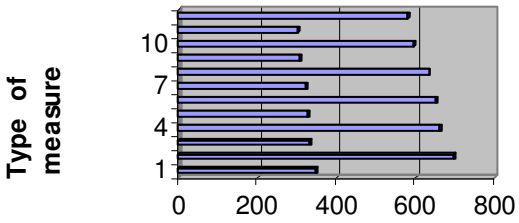

Fig. 1 The relation between restricted water and unrestricted water in Heddah city between the year of 1990 and 2000.

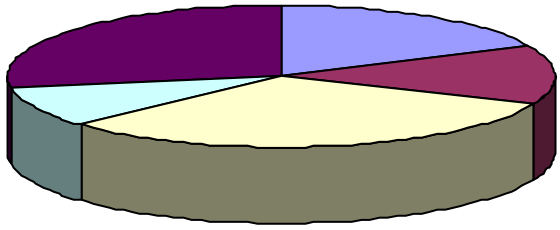

Fig.2 The cumulative % of conserved water according to type of measure in Jeddah city in the year 1990

References

Albraithen, M.I. 1993 Municipal water demand management. Ph.D. Colorado State University.

Baumann, D.D. 1990 The role of conservation in urban water supply planning, planning and management consultants, carbondale, Illinois.

Baumann, D.D., and Daniel M. Dworkin. 1975 Water reuse practices, prospects, and proble3ms. U.S. Army Engineer Institute for water resources report on seminar, contract no. DaCW31-75-M1344 and DACW31-75-C-0199.

Baumann, D.D. and E. Kasperson. 1974 Public acceptance of renovated wastewater: Myth and reality. Water Resources Research, 10:667-74.

Danielson, L.E. 1979 An analysis of residential demand for water using micro time-series data. Water Resources Research vol.15, No.4.

Davis, D. and Haines, B. 1987 Political Institutional Factors affecting efforts to conserve water in Washington State, Washington State University, Washington Water resources Center and department of Political science, p.71.

Davies, W.Y. 1987 IWR-MAIN water system, version 5.1; User's Manual and System Description prepared by PMCI, Carbondale, Il for Water Resources Support Center, U,S. army Corps of engineers.

Development Analysis Associates 1978 Water conservation and reuse-Domestic Section. Report prepared for the saline water conservation corporation Kingdom of Saudi Arabia.

Griffith, E.L. 1978. Southern California's drought response program. J. of Am. Water Works assoc. 70:74-78.

Hanke, S.H. 1970 Pricing as a conservation tool - an economist dream come true? In: Municipal water systems: the challenge for urban resources management. D. Holtz and s. Sebastian. Bloomington: Indiana University Press.

Kempe, M. Lahage, B. and Yeo, J. 1990 Workshop on water conservation, Massachusetts water resources authority, Boston, Massachusetts, U.S.A.

Rubinstein, J. et al. 1984 Water conservation and capacity expansion, J. of Water Resources Planning and management. ASCE, vol. 110, No.2.

Sorman, a. U. and AbdulRazzak 1994 Water conservation strategy for Saudi Arabia. Hydrology and Water Resources Management Dept., King Abduaziz University.

Williams, M. and Suh, B. 1986 The demand for urban water by costumer class. Applied Economics, Vol. 18.