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Effectiveness of means used for water demand control

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ABSTRACT

The amount of water extracted for municipal, agricultural and industrial purpose has been about 36.6% of total run-off in Korea. The long-term water resources plan by the Ministry of Construction and Transport predicted approximately 340 million tons of water shortage in 2011. Based on the prediction, construction of a new dam was necessary. The Ministry of the Environment (MOE) launched the Water Demand Control Plan in the year 2000 to save 790 million tons of water to avoid construction of new dams. In 2003, the MOE evaluated the achievement of the Control Plan and declared the Plan successfully saved about 450 million tons of water per year using several means. The declared achievement has been examined using the water statistics between 1999 and 2004. The analysis has revealed that the conservation has not been as successful as declared. Actual reduction in water production between in 1999 and in 2004 was only about 116 million tons instead of 450 million tons that the MOE announced. Probably the MOE might have saved water through the Control Plan to a certain extent. However, that has not meant the budget has been allocated properly and used efficiently. Raising water revenue and substituting existing faucets for water-saving devices might not have any considerable effect in conserving water consumption. If any institute really wants to control water demand, it needs to analyze the effectiveness of all methods implemented.

Keywords: Conservation; Demand control; Leak; Water-saving devices; Statistics

1. Introduction

Water is one of essential resources for a country to support its citizens' life, agriculture and industrial development. International institutes such as UNEP have regarded that the proper water draft rate to total water yield would be in the range between 10 and 20%. If the draft rate is between 20 and 40%, the water stress would be high enough to prepare an intensive water conservation plan. When the rate is over 40%, the water environment would be damaged profoundly. An emer-gency plan may be needed at this stage.

Korea has rain mostly between July and October. More than two-thirds of the total yearly precipitation may be encountered during these months. The average slope of river beds is steep enough for rivers to stay only several days in land. The circumstances for water resources have been harsh enough not to support satisfactory use of water if many multipurpose dams had not been constructed. In the year 1999, the amount of water used for municipal, agricultural and industrial purposes was about 33.1 billion tons in Korea. This is about 36.6% of total run-off [1].

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It had been estimated that the population was 47 million in 1999, and it might be increased to reach a maximum of 50.6 million in 2023. The water use per capita may be increased due to the enhanced life style in the small cities and rural areas. The long-term water resources plan by the Ministry of Construction and Transport predicted about a 340 million ton total water shortage in 2011. However, additional construction of dams would not be feasible due to the objection by residents. Thus the Water Demand Control Plan was launched by the Ministry of the Environment (MOE) in 2000 and its target has been the conservation of 790 million tons of water by 2006.

Several means were selected to save water: raising the water rate, reuse of wastewater, replacement of leaking distribution lines, substituting shower-heads, faucets and the current water service apparatus for water saving ones. In the year 2003, the MOE evaluated the achievement of the Demand Control Plan and its implementation [2]. The MOE, by itself, has concluded that the means and the policy have been successful, conserving about 450 million tons of water by 2002. However, it would be meaningful to evaluate the declared achievement of the MOE using the national water statistics to determine which methods had really been effective. The evaluation results could be a reference for any institute to establish a water conservation plan.

2. Water Demand Control Plan established in 2000

The classification of municipal water supply is listed in Table 1 and statistics for municipal water use in 1999 are summarized in Table 2. The MOE has prepared a water conservation plan shown in Table 3 in the year 2000. The plan has expected to save 290 million tons per year by installing water saving service apparatus, 200 million tons per year by raising water revenue and 240 million tons by replacing leaking distribution lines.

By the year 2002, the MOE has supported a project furnishing 9.5 millions of water saving apparatus in houses, public offices and schools. About 28.9 thousands shower heads and faucets at commercial saunas have been substituted for water saving devices under the enforcement by regulation. The MOE has declared that about 214.3 million tons of water have been saved by the year 2002 due to the installation of water saving devices.

The MOE also has assigned 1 billion US $ to replace 8,716 km of leaking distribution lines. The MOE has estimated that the leak rate has been reduced from 16.1% in 1999 to 13.9% in 2001 saving 104.6 million tons of water. The MOE has allowed raising the water revenue. Until 1999, the water rate had not reflected the actual production cost because the water revenue was considered as one of the most affecting items on living cost. The revenue was raised to 51cents/ton in 2001 whereas the revenue was 41cents/ton in 1999. Still the water revenue in 2001 reflected only 85.9% of production cost. The MOE has estimated that about 114.1 million tons of water were saved due to raising the rate [2].

Table 1
Classification of municipal water supply in Korea

Effective use	Billed authorized consumption	Domestic Commercial Business Sauna Industrial
	Unbilled authorized consumption	Public service Waterworks
	Apparent loss	Error caused by water metering
Non-effective use	Real loss	Adjusted amount due to correction Leakage

Table 2
Water use in 1999 [1]

		Total amount (million t/y)
Billed consumption	Domestic	2,655
	Business	581
	Commercial	661
	Sauna	99
	Industrial	262
Unbilled authorized consumption		606
Real loss (leakage)		934
Total		5,798

3. Examining effectiveness of each implementation means by water statistics

Each city and provincial waterworks report water statistics to the MOE every year and the MOE publishes collected water statistics in December. The statistics for 2004 were published in December, 2005. The total production, amount of effective use and non effective use from 1999 are summarized in Table 4. As the total production in each year was compared, total production in 2002 did not decrease appreciably. The yearly water production was 5,812 million tons in the year 2000 when the Water Demand Control Plan was initiated. In the year 2002, the water production was 5,696 million tons [5]. Actual saving in production was only 116 million tons

Table 3
Water Demand Control Plan for 2006 [2]

Policy		Implementation means	Conservation (million t/y)	Rate (%)
Total		—	790	100.0
Subtotal		—	290	36.7
Installing water-saving devices	Domestic use	Replacing 11.6 million devices	250	31.6
	Commercial use	Replacing 11,500 devices	40	5.1
Raising water revenue		100%	200	25.3
Reducing water loss rate		Replacing old distribution line	240	30.4
Reuse of wastewater in building		300 places	30	3.8
Industrial water recyling		Saving 10% of total water use	30	3.8

Table 4
Statistics of water production and use from 1991 to 2004

Year	Total production (m.t/y)	Effective (m.t/y)		Non-effective (m.t/y)	
		Paid	Unpaid	Adjusted	Leaked
1999 [1]	5,798	4,257.695	605.985	0.283	934.456
2000 [3]	5,812	4,342.479	610.195	0.259	858.753
2001 [4]	5,791	4,367.111	618.673	0.364	804.367
2002 [5]	5,696	4,395.158	597.723	2.460	700.245
2003 [6]	5,723	4,489.479	450.380	1.816	781.056
2004 [7]	5,909	4,633.080	433.791	2.955	839.352

although the MOE declared the control plan was successful in saving 450 million tons of water [2]. It might be meaningful to analyze the effectiveness of implementation means using water statistics to be referred to in future demand control plans and implementation.

3.1. Effect of raising water revenues

One thing that has to be observed to evaluate the effectiveness of raising water revenue is the change in consumption of paid water. If raising water revenues were effective in demand control, the consumption of paid water should be decreased. However, the consumption of paid water per capita per day was 285 L in 1999 [1], 280 L in 2002 [5] and 287 L in 2004 [7], whereas the water revenue was 0.31 $/m^3$ in 1999, 0.40 $/m^3$ in 2002 and 0.42 $/m^3$. The consumption was not reduced appreciably although the water revenue increased about 40%.

The fact that paid water consumption did not decrease appreciably means that the increase in water revenue was not effective in water conservation. The average water bill for a household was less than 20 US $ for a month. The official GDP of Korea was 9,550 US $ in 1999, 11,486 US $ in 2002 and 14,161 US $ in 2004. Average income of a household in urban reached about 3,000 US $ per month in 2002. The lowest 20% household earned about 1100 US$ for a month. In this situation, the 40% increase in the 20 $ monthly water bill might not have any impact to restrict water use.

3.2. Effect of furnishing water-saving devices

No appreciable reduction in paid water consumption also indicated that 9.5 million water-saving apparatus replaced in household did not bring any remarkable reduction in water consumption. The domestic water consumption accounts for about 50–60% of paid water consumption. If the water-saving devices had any practical effect, the yearly trend per capita water consumption should be decreased rather than the plot shown in Fig. 1.

The most proper way of confirming the effectiveness of water-saving devices would be investigating the water consumption in commercial saunas. Since the regulation forced the substitution of all the faucets and shower heads

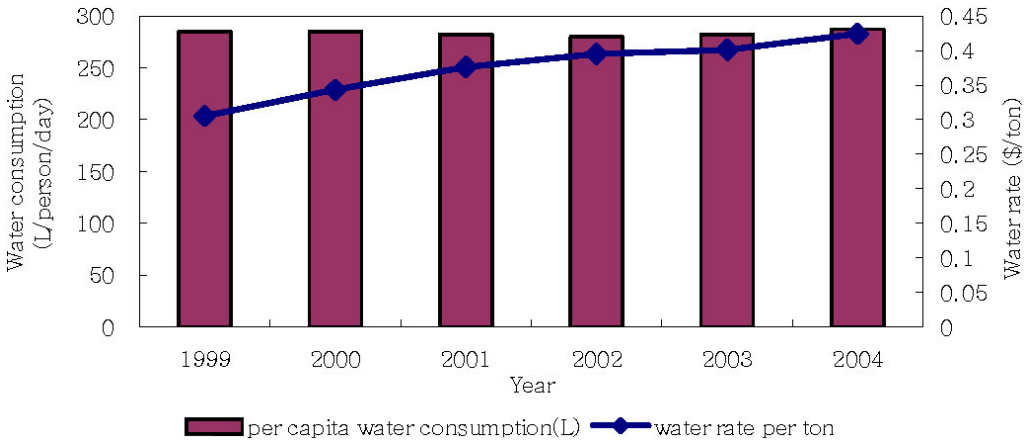

Fig. 1. Recent trend of paid water consumption and water rate.

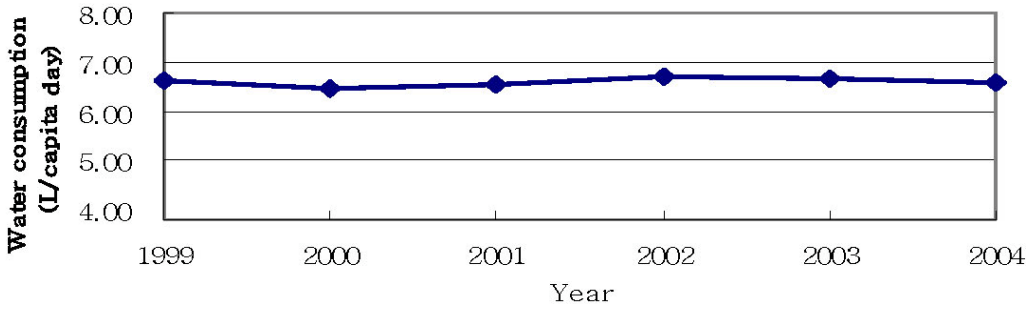

Fig. 2. Per capita water consumption in sauna in each year.

for water-saving service devices, about 90% of all the faucets and shower heads were replaced by the year 2002 and 100% were replaced by 2004. The per capita water consumption in sauna is also plotted in Fig. 2. The per capita water consumption in commercial sauna was 6.62 L/d in 1999 [1] and 6.72 L/d in 2002 [5]. In 2004, the water consumption was 6.6 L/d per capita [7]. Practically no difference was observed in water consumption.

The effect of replacing faucets and showerheads could not be found from the statistics. Usually the water-saving faucets would be at the open position for a designated time. It could be presumed that if the time limit is 1 min, the faucet should be pushed twice when a consumer needs 1 min 10 s to wash his body. There might be wasted water for 50 s. The reason why the water-saving apparatus did not contribute to decreasing water consumption has not yet been thoroughly explained. In any case, the statistical survey implied that the budget assigned by the MOE to install water-saving faucets has been in vain. Therefore, the effectiveness of water-saving devices should be investigated in detail for future planning of efficient water conservation.

3.3. *Effect of leak control*

Three implementation means selected by the MOE to reduce water consumption were increasing water revenue, substituting faucets for those having a water saving function and replacing leaking distribution lines.

Table 5
Leaking in large metropolitan areas and provinces for each year [1,3–7]

Area	2000	2001	2002	2003	2004
Metropolitan:					
Seoul	264.3	208.5	142.5	195.5	157.8
Busan	81.4	58.4	44.6	43.3	44.7
Daegu	47.5	43.9	36.5	44.8	59.2
Inchon	57.8	54.4	51.5	51.1	57.1
Kwangju	17.8	15.8	16.0	15.7	14.8
Daejun	32.2	31.6	23.6	22.4	22.2
Ulsan	13.4	13.3	11.9	13.9	21.6
Provinces:					
Kyung-Gi	108.2	114.8	108.0	109.3	112.1
Kwang-Won	28.4	33.3	31.1	37.2	49.5
Choong-Book	17.0	15.4	15.6	15.7	17.5
Choong-Nam	15.4	17.3	17.8	19.0	26.2
Jun-Book	42.3	47.1	44.1	44.9	50.6
Jun-Nam	30.9	31.5	30.0	32.0	42.5
Kyung-Book	39.7	51.2	50.0	51.4	70.3
Kyung-Nam	52.9	58.5	67.9	75.6	83.8
Jeju	9.6	9.3	9.2	9.3	9.4

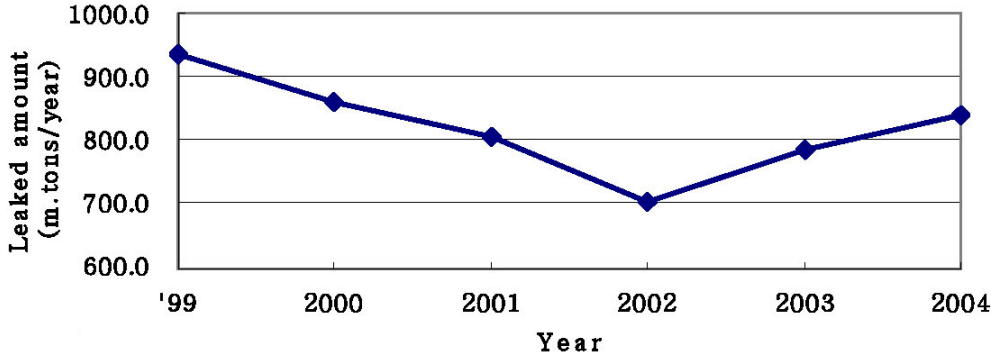

Fig. 3. Amount of total leaked water in each year.

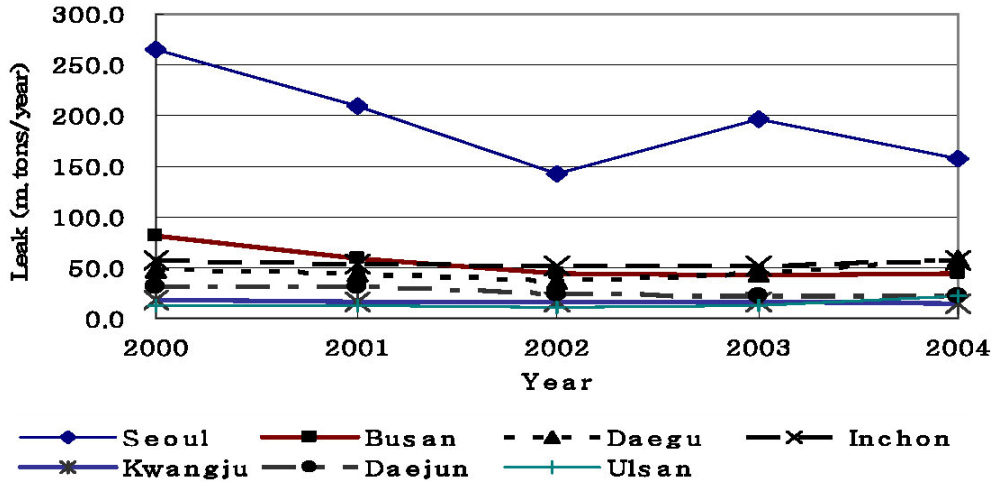

Fig. 4. Amount of leaked water in seven metropolitan areas in each year.

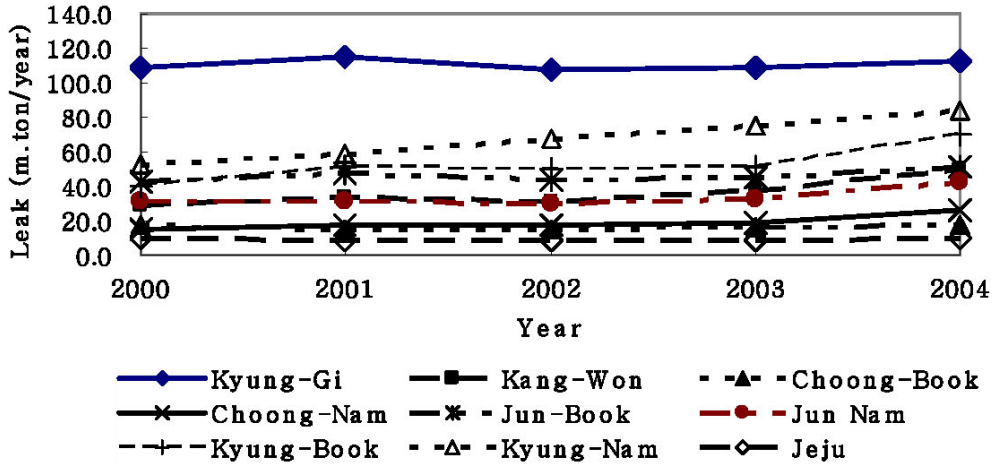

Fig. 5. Amount of leaked water in nine provinces in each year.

Two out of three means turned out to have no effect in reducing water consumption as evaluated statistically. However, leak control was effective in reducing water demand. The amount classified to non-effective use in the statistics denotes leaking from the distribution network. The leaked amount in statistics is plotted in Fig. 3. The total leak was 934.5 million tons in 1999. The amount decreased to 700.2 million tons in 2002 and increased to 839.4 million tons in 2004. The reduction has been 234.3 million tons at most and 95.1 million tons in 2004 when

compared to 1999. The leak control seemed to be the only effective way of conserving water.

However, if the statistics from large metropolitan areas and provinces are investigated (Table 5), it is found that the reduction in total leaks mainly resulted from the reduction in Seoul and Busan. The reductions from other large cities were not so remarkable and, the leakage in Ulsan was increased in 2004 compared to the year 2000. The leaks in all the provinces were increased rather than decreased. It has been revealed that the water conservation appeared in national water statistics mainly due to the leak control by two major metropolitan areas. Leak control is known as a very troublesome job. When one leaking crack is repaired, the adjacent cracks start to leak due to the pressure shifting to the adjacent cracks. A very professional job is required to achieve the expected reduction.

4. Conclusions

The Ministry of Construction and Transport estimated about 340 million tons of water shortage in 2011. Based on the estimation, construction of new dams is necessary. The MOE established the "Water Demand Control Plan" in the year 2000 to save 790 million tons of water per year by 2006. In 2003, the MOE evaluated the effectiveness of the Plan and declared the Plan was successful in saving about 450 million tons of water in a year. The achievement has been examined using the water statistics between 1999 and 2004. The analysis has revealed that the conservation has not been successful as declared. The actual reduction in water production was only about 116 million tons instead of 450 million tons that the MOE declared. Raising water rates and replacing faucets did not have any significant effect in reducing water consumption. Only replacing old pipes has shown a noticeable effect in reducing water consumption.

Therefore it could be regarded that the MOE has devoted itself to non-efficient means. If the MOE really wants to establish an effective conservation plan in the future, it has to analyze carefully how much each implementation means has been effective and why some means have failed in achieving the expected conservation. That should be the most urgent issue for the MOE to use its budget efficiently.

Acknowledgment

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