"Reclaimed Water" Price Research In Beijing Communities

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Abstract. China is one of the most serious countries in the world for shortage of water resources per capita. As a kind of recycled water within a certain range, reclaimed water can effectively lower the pressure. However, in the domestic, the usage of reclaimed water has not been widely popular and its economic and environmental benefits have not been fully explored. To solve this problem, firstly, a survey was carried out and the price was found to be an important factor. Secondly, after deep research, the treatment methods and the scale of using the reclaimed water were supposed to be the important factors that leaded to price differences. Thirdly, through data analysis and economic model, the best price of Beijing in water treatment with good quality was calculated out.

Keywords: Usage of claimed water; Promotional programs; Community research; Benefit and efficient evaluation.

1. Introduction

China is one of the most serious countries in the world for lack of water due to the large population. The water resources consumption per capita is only a quarter, listed as one of the most serious shortage of water per capita in the world. Furthermore, water scarcity becomes a bottleneck of national economic construction and development for the rapid urban population growth, environmental degradation, the backward technology in industrial and agricultural water and so on.

In order to solve the problem of water shortage, the western developed countries attach great importance to the protection and utilization of water resources [1,2]. They have also invested heavily in water recycling, public education, research, innovation and facilities to ensure the efficiency of water recycling and conduction orderly. China's applications of reclaimed water are relatively large in Beijing, Tianjin, Qingdao and other developed regions, but the overall development is still insufficient.

Through research, the price of water and the water quality have been found to be the main factors in the promotion of the reclaimed water. The paper aims to establish a water pricing model to seek the lowest price of reclaimed water in Beijing under good quality situation for the future promotion.

2. Price Model Of Reclaimed Water

A model is used to find the optimal water price in water prices. Through research, the price of reclaimed water has been found to be between ¥2 and ¥3, while the quality and the price have great influences on the amount of reclaimed water. There are two main factors affecting the price, one is the water treatment method and the other is the scale of the water use. The better the water treatment methods are, the more expensive equipment should be needed. The larger the scale of water use is, the higher costs of pipeline are. After simple analysis, a model is built to balance the bond of equipment, the size of distinctions and water usage to get a best price for the promotion of reclaimed water to save water and reduce sewage discharge purposes.

According to collecting data and research, we summarize the three typical water treatment methods: after secondary treatment and reuse (Scheme 1), after tertiary treatment and reuse (Scheme 2), and after MBR treatment [3, 4] and reuse (scheme 3). After analysis of three options on the water price, the price per cubic meter of water is given corresponding to each program. As for calculation in water treatment method, Xishan district of Yicheng is used as a research object (the district has 330000m^2 areas, the volume rate is 1.2%, the green areas is 30 percent, it has 3,500 households,

10,500 people and 891 vehicles). The age of the equipment is 25 years and the age of the pipeline is 50 years.

2.1 After secondary treatment and reuse (Scheme 1)

Features:

(1) It belongs to the traditional form of treatment with mature technology, low sludge production and less investment in equipment;

(2) The resource is sewage (excluding stool) and it requires implement the diversion between manure drainage and sewage;

(3) The water balance is very difficult for the seasonal changes of its flow;

(4) Water quality can only reach the requirements of flushing and greening.

Equipment Specifications：

Design capacity q=500m3/d; Regulating cell volume v1=0.4q=200m3;

The tank volume v2=0.25q=125m3;

Reclaimed water supply pump q1=2.5*452/24=47.2m3/h;

Water pressure p=392k pa□441k pa; Power n=4kw.

The results are calculated as follows:

Table 1 Analysis on running cost (Option 1)

Depreciation on pipe network	Depreciation on equipment	Processing fee	Electricity fee	Labor costs and others	Totals
1.44	0.07	0.64	0.4	0.24	2.79

2.2 After tertiary treatment and reuse (Scheme 2)

Features:

(1) It belongs to the traditional form of treatment with mature technology, high sludge production and more investment in equipment;

(2) The resource is sewage (including stool), but it doesn't require implement the diversion between manure drainage and sewage, reducing the initial investment cost in pipes.

(3) Water is sufficient with the small flow in seasonal changes

(4) Water quality can only reach flushing and greening requirements.

Power design capacity q=500m3/d ; Regulating cell volume v1=0.4q=200m3;

The tank volume v2=0.25q=125m3;;

Water supply pump q1=2.5*452/24=47.2m3/h;

Water pressure p=392k pa□441k pa; Power n=4kw.

The results are calculated as follows:

The second program operating costs analysis as follows:

Table 2 Operating cost analysis (Option 2)

Depreciation on pipe network	Depreciation on equipment	Processing fee	Electricity fee	Labor costs and others	Totals
0.77	0.11	0.91	0.4	0.36	2.5

2.3 After MBR treatment and reuse (scheme 3)

Features:

(1) It belongs to a new type of treatment process with sludge production and the use of PLC-controlled minimal. It is easy to operate but requires more investment in equipment;

(2) The update of film will increase operating costs;

(3) The resource is sewage (including stool), but it doesn't require implement the diversion between manure drainage and sewage, reducing the initial investment cost in pipes.

(4) Water is sufficient with the small flow in seasonal changes;

(5) The water quality is good and it can be used to wash cars except for flushing and greenery.

Equipment Specifications:

Design capacity q=600m3/d; Regulating cell volume v1=0.4q=240m3;

The tank volume v2=0.25q=150m3;

Reclaimed water supply pump q1=2.5*469/24=48.9m3/h;

Water pressure p=392k pa□441k pa; Power n=4kw,

The results are calculated as follows:

Table 3 Operating cost analysis (Option 3)

Depreciation on pipe network	Depreciation on equipment	Processing fee	Electricity fee	Labor costs and others	Totals
0.69	0.18	1.0	0.4	0.14	2.41

By calculation, water per cubic meter in program 3 is the lowest price. Although the depreciation of the cost of water treatment and equipment increased, but due to the improvement of water quality, the usage of the amount of water increases, reducing the price per cubic meter of water treatment.

2.4 Water use scale:

Taking into account of the current cell which is configured separately in the water treatment system, the limited amount of water and the low rate of processing equipment utilization are the very important factors affecting the price of reclaimed water [5]. So, a new program is proposed that the districts nearby will be united together to do unified water treatment, which can improve the utilization and disposal costs of equipment to achieve the purpose of lowering prices. According to the site analysis of water treatment plant, the best position in the water treatment station to make the shortest length of the pipe is found with the most short-circuit diagram analysis under the theory by computer programming.

According to the principle of the shortest path, we can get the shortest path optimization function:

$$f(x,y)=\sum_{i=1}^{n}\sqrt{(x-x_i)^2+(y-y_i)^2}$$

By mathematical programming, the relationship image between the shortest path and the variables is shown as follows:

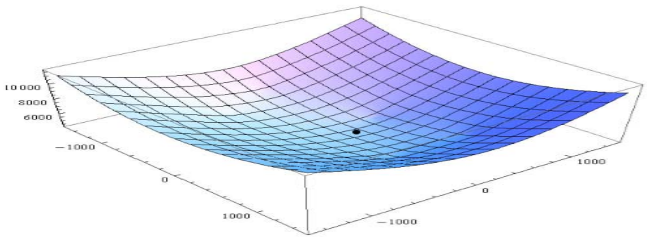

Figure 1 Shortest path

Five districts of Haidian District in Beijing are chosen to do model analysis. Form the figure below, it is clear that the function has the minimal value point. The location of the minimum value of the point is the position of water treatment plant (coordinates -87.23, 259.54). The coordinate position in the water treatment plant and the cell are shown below:

Figure 2 Map of five communities

After gathering information, total construction areas of each cell have been got in the following table:

From the previous step in the water treatment process model, the Scheme 3 is the best with the lowest price per cubic meter of water, so it is chosen in the scale model calculations. It can be seen as the increase of size in cells with five cells joint in water treatment, resulting that the size of the cell increases sharply in water. According to estimate, one equipment cannot meet the demand for its

capacity, we will increase it to three. Total construction areas are 1245000m^2, the volume rate is 1.2%, green areas are of 30 percent, it has 41,085 househoods, 123,255 people and 3,362 vehicles.

Table 4 five residential construction areas

Name of Communities	Areas
Chrysanthemum Distinct	270000㎡
Xishan District Of Yicheng	330000㎡
Xianghuangqi Distinct	200000㎡
Baiwangjia Distinct	277000㎡
Wu Xiu Garden Distinct	168000㎡

Table 5 Analysis on operating cost (Option 4)

Depreciation on pipe network	Depreciation on equipment	Processing fee	Electricity fee	Labor costs and others	Totals
0.7	0.14	0.48	0.4	0.06	1.78

The Results are obtained as follows combined with the four scenarios.

Table 6 Reclaimed water price per unit in four scenarios

Programs	The price of water processing per square meter
Program 1	2.79
Program 2	2.5
Program 3	2.41
Program 4	1.78

According to the data from the table, we can get that it can greatly reduce the price per square meter of reclaimed water to make the use of it larger to achieve the purpose of energy saving by expanding the scale of reclaimed water and use MBR treatment and reuse program.

3. Conclusion

Nowadays, in the background of national vigorously promotion of "sustainable development" and the adjustment of resource utilization in the structure, "reclaimed water" will also be the trends. In the next few years, under the double stimulated national policy support and technical guarantees, "reclaimed water" will enter into a new period of development. Our study contributes to the promotion of water in the national unified planning, making the prices lower with the assurance of water quality to make residents better accept and use it.

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