

## Water treatment process costs estimate

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**Keywords:** water treatment process costs, Billings, fitted curves

**Abstract.** After finishing the work of searching data, we get the process of the recycled water treatment flow in Billings. By means of understanding the production process, we divide the costs of the recycled water into two parts, which contains pipe-construction costs and water treatment costs. The water treatment costs contains the all costs in the recycled water treatment process. We mainly estimate the cost of water treatment process. We deprive the recycled treatment costs by the curve fitting model to get the costs of the recycled water. After that, an extended model will be proposed to derive the maximum profits about the recycled water's distribution.

### Introduction

With the development of GDP, personnel income and the population in the world, the phenomenon of shortcoming of the water become more austere in everywhere in the world. Thus, to realize the long-time development, recycled water is of great importance. Accurate estimation of the cost of water treatment is essential.

### The process of the recycled water treatment flow

After we finished the work of searching data, we find that the process of the recycled water treatment flow is as follows:

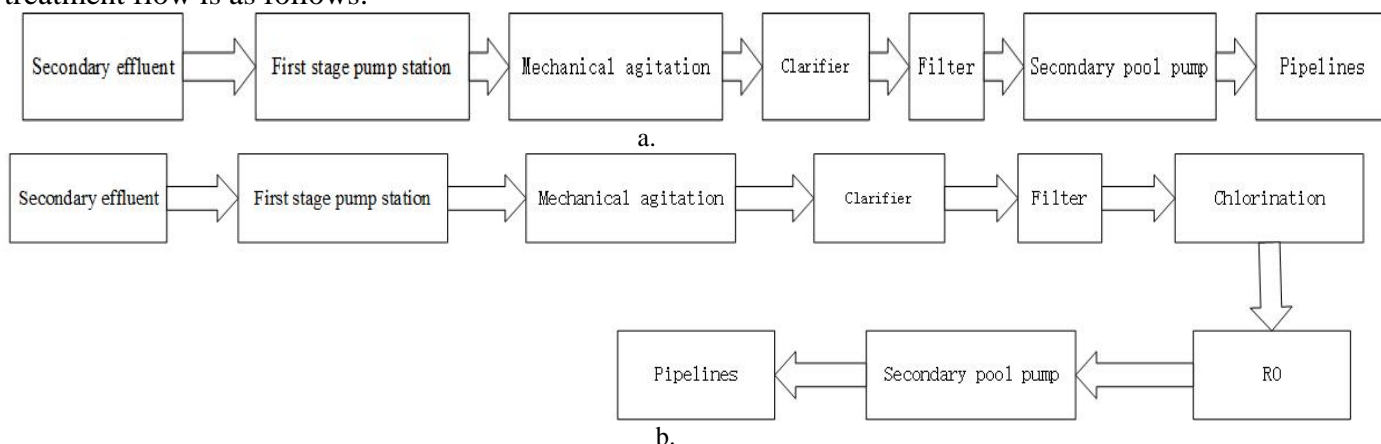


Fig 1: The process of the recycled water making.

- a. The water- treatment process of the non-potable recycled water.
- b. The water- treatment process of the potable recycled water.

### The water treatment process costs

The water treatment process costs contains the equipment costs and the costs of treatment. By means of the data-researching, we know the costs of building a clean tank and a pump and the costs of sewage treatment equipment about the filter, Chlorination, RO. Based on this data, we imitate some fitted curves of the treatment buildings costs. After that, we derive the mathematics models of all the treatment buildings.

Table 1 The mathematics models about the costs of all the treatment buildings

The treatment buildings	The mathematics models
Clean water tank	$y = 7.8504x^2 - 24.8528x + 85.2371$
Water pump	$y = 3.1086x^2 + 24.1619x + 28.8053$
Mechanical agitation	$y = 23.8015x^2 - 11.2279x + 50.3699$
Filter	$y = 0.5837x^2 + 94.6499x - 32.7785$
Chlorination	$y = 3.5982x^2 + 65.2234x + 29.2928$
RO	$y = 14.1920x^2 - 9.9802x + 50.6676$

Using the models in table 1, combining with the water demand we had got in the question one, we reach the result of the costs of the recycled water by the following image:

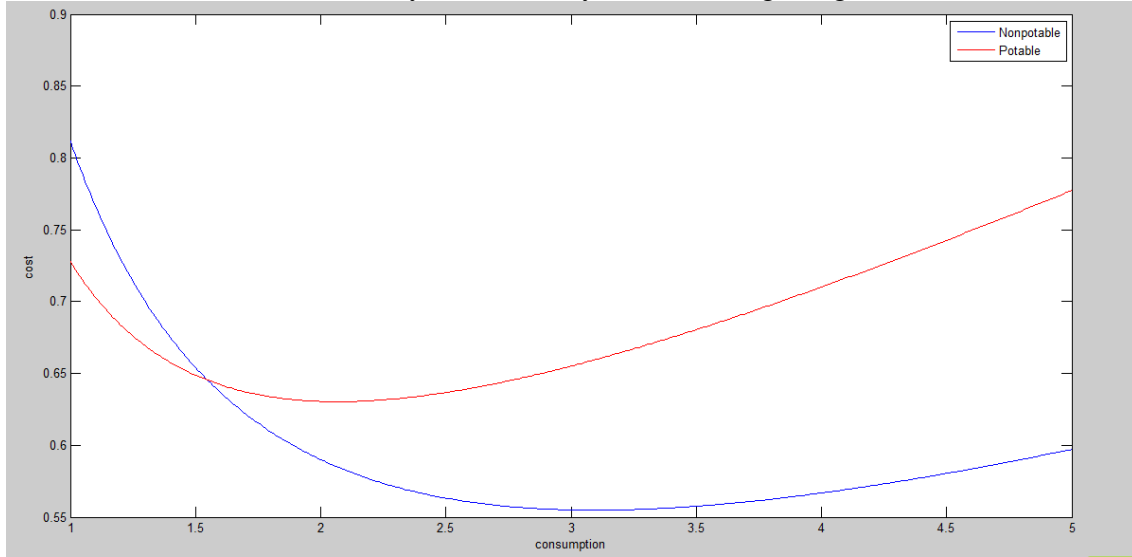


Fig 2: The costs of the recycle water.

We discuss the cost of water per cubic meter. From this figure, we find that the costs of the non-potable water is higher than the potable one when the day water demand less than 16 thousand cubic meters, because transmitting the non-portable water need to build new pipelines, which is very expensive. When the demand is more than 16 thousand, the costs of the portable recycled water is more expensive than the non-portable one.

Furthermore, we find there are two nadirs in the figure. That is, the potable water is cheapest in the condition that the demand is 33 and the costs is 0.5549 dollars per cubic meters. These two values for the non-portable water respectively are 20 and 0.6339.

As far as we concerned, the probable price of tap water is 0.74 dollars. According to our prediction, the demands of the recycled water is range from 10 to 45, is right in the range of the low valued area and is similar to the tap water price, is adaptive to product.

### Extended Model

Under the basement of question two, we discuss the distribution of the potable recycled water and the non-potable recycled in order to get the minimum cost of recycled water.

Assume  $q$  is the quantity of demand water per day, and the rate of producing sewage is  $\eta$ .

So, the quantity of sewage is:

The part of  $Q^* \alpha$  should be transformed into potable water and the rest of sewage should be transformed into non-potable water. Because of the limitation of technology, there is a rate of transformation,  $\beta_1$  and  $\beta_2$ .

So  $q_1 = Q \alpha \beta_1$ , which is the quantity of potable water,  $q_2 = Q (1 - \alpha) \beta_2$  is the quantity of non-potable water.

Meanwhile assume  $\text{cost}_1$  is the cost of potable water, and  $\text{cost}_2$  is the cost of non-potable water.

$Q_1$  is the quantity of the demand of water . $Q_2$  is the quantity of the demand of drinking water.

Under the situation that the quantity of drinking water and the amount of water is both enough, we want to get the minimum cost of recycled water,

$$\min = \text{cost1} + \text{cost2} + \text{cost3} \quad (1)$$

$$s.t. \ q_1 + q_2 + q_3 \geq Q_1 \quad (2)$$

$$q_1 + q_2 \geq Q_2 \quad (3)$$

Concerning the specific method, we simplify the model .We let that q is 615 thousand cubic meters,  $\eta=0.1$  , $Q_2=0.4 Q_1$  , $\beta_1=0.6$  ,  $\beta_2=0.8$ .

cost1=0.7218 dollars per cubic meters, cost2=0.6862 dollars per cubic meters, cost3=0.7463 dollars per cubic meters ,  $\alpha=0.37$  ,  $q_1=13.65$  thousand cubic meters,  $q_2=30.99$  thousand cubic meters,  $q_3=570.4$  thousand cubic meters. We can get the minimum cost of recycled water is 456.8 thousand dollars.

Table 2 The results of the extended model

variation	value
cost1	0.7218
cost2	0.6862
cost3	0.7463
$\alpha$	0.37
$q_1$	13.65
$q_2$	30.99
$q_3$	570.4
cost	456.8

## Summary

Because the costs of potable recycled water is higher than the non-potable one, in the view of the profits, the factory should try to product more non-potable water to get more profits. However, considering the sustainable development, the government should try their best to spread the recycled water to enlarge the amount of the users. Meanwhile, helping the producer to develop the technology of its production and rise its production efficiency to give more benefits for the sustainable development. Thus, the government can take the measure of give the people some water allowance. What's more, we find that the cost of recycled water is 0.7436 dollars per cubic meters. As a consequence, when the cost of non-potable recycled water is lower than the tap-water, we can purchase the sewage from the surroundings city to product more recycled water to do more things.

## References

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