

Plan for recycling water in Billings

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Keywords: interpolation curve, water consumption, correlation coefficients.

Abstract. This paper mainly focuses on providing a plan for recycling water in Billings. We divide urban water consumption into living water consumption, industrial water consumption and public water consumption. Using interpolation curve fitting, we separately predict the water consumption in these aspects above. Our forecast result is that 165.67 billion cubic meters water will be consumed in the future 30 years. In addition, we use power function in model 2 to optimize model 1. Then, the number turns to 173.40. In the sensitivity, we analysis several correlation coefficients that mainly influence the results separately.

1. Introduction

Recycling water is a kind of method appropriately disposing industrial waste water, coming from a closed cyclic water system composed by a factory, a workshop, a water supply system and a drainage system (as shown in Figure 1). In this process, there will be no supplement or a little supplement of fresh water, and no discharge or less discharge of waste water in the meantime ^[1].

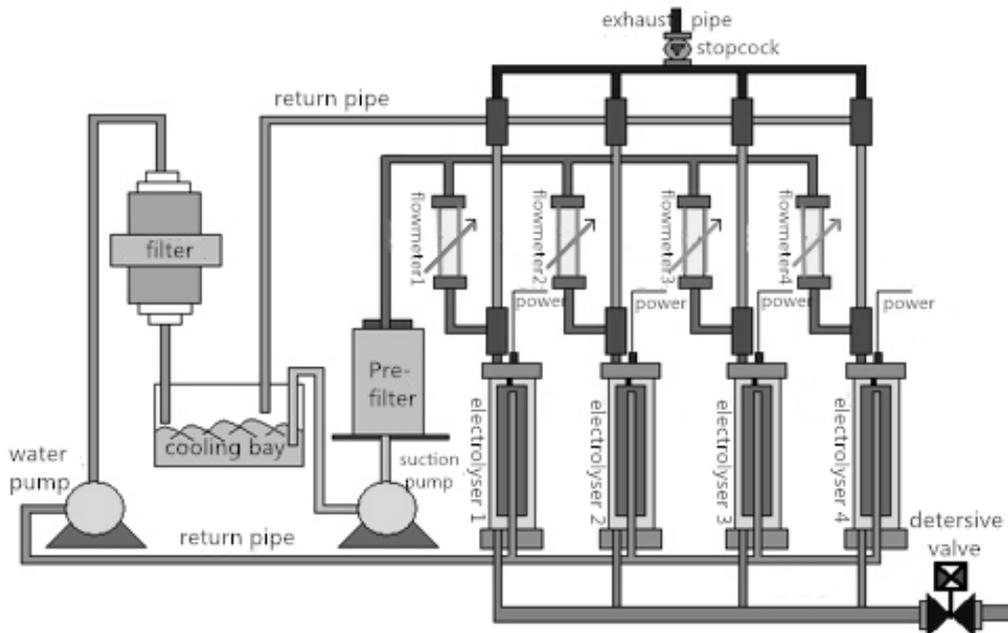


Fig. 1: Industrial waste water treatment system.

We analysis the urban water consumption of Billings consist of living water consumption, industrial water consumption and public water consumption. To face the Shortage of water resources, forecasting and analyzing the total water consumption of Billings in the next 30 years will make sense.

2. Model Theory

2.1 Model Overview

The below part of figure 2 shows the flow chart of sewage treatment. In this procedure, sewage treatment process is a pure physical process, there is no chemical reaction in it. In addition, the concentration of the waste water is settled ^[2].

The urban sewage can be separated into three aspects, the living waste water, the industrial sewage and the public waste water, The flow of them is same as 5×10^{12} L/min while they inflow into the recycling facility ^[3]. The maximum of the industrial sewage is 100mg/L, the living waste water is 30mg/L, and the public sewage is 10mg/L in the same time. The non-potable water's sewage concentration should be less than 1mg/L, while the concentration can't rise to 0.1mg/L in the potable water ^[4].

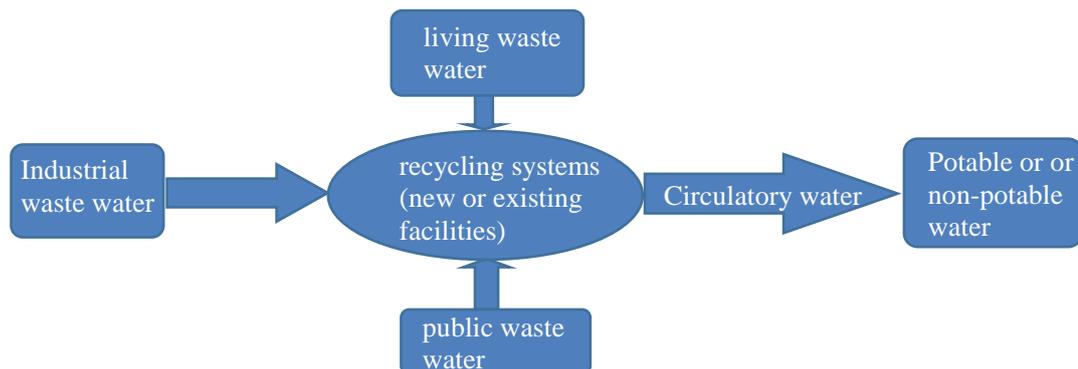


Fig. 2: Sewage treatment's flow chart

2.2 Basic Model

Step1. Model Analysis:

First of all, in the Statistical Abstract of United States, we figure out seven years of urban water consumption in Billings from 2002 to 2008, Then, we get a series of discrete data consist of living water consumption, industrial water consumption and public water consumption ^[5]. Then we use MATLAB to fit a linear function to urban water consumption of Billings from 2002 to 2008.

Two forces act on the function: Particular year(x), annual urban water consumption(y).

$$y = 0.962642857143 \cdot x - 1901.509642857196 \quad (1)$$

Then, we draw out the scatter plot and the fitting curve (as shown in Figure 3).

The predicted result turn out to be that 1.662158e+003 billion cubic meters of urban water will be consumed.

Step2. Living water consumption:

Two forces act on the function: Particular year(x), annual living water consumption (y_1).

$$y_1 = 0.2037 \cdot x - 405.1 \quad (2)$$

Then,we draw out the scatter plot and the fitting curve (as shown in Figure 4).

The predicted result turns out to be that 2.670557e+002 billion cubic meters of living water will be consumed.

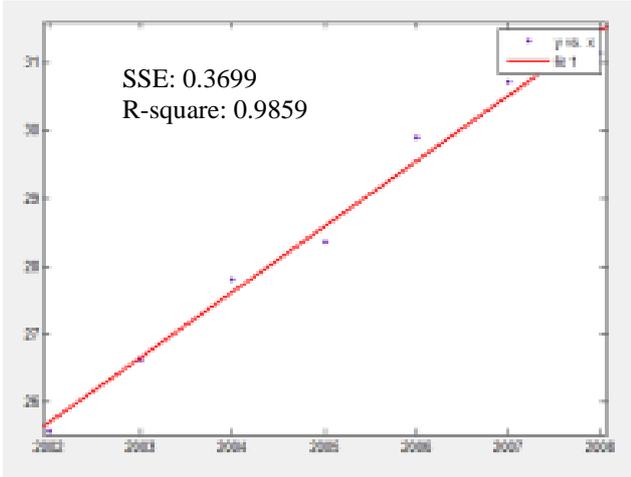


Fig. 3: Urban water consumption

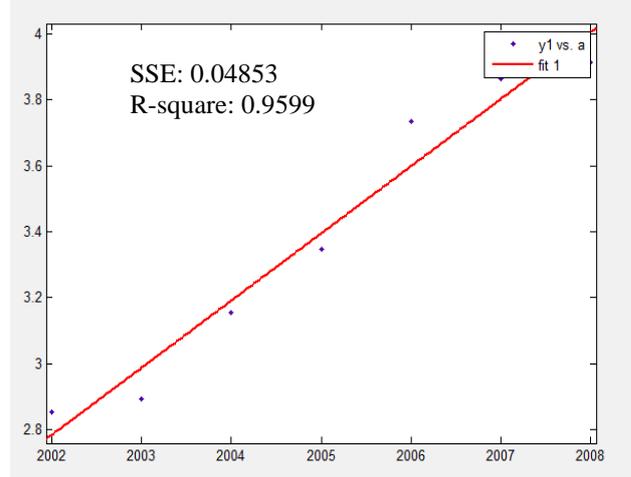


Fig. 4: Living water consumption

Step3. Industrial water consumption:

Two forces act on the function: Particular year(x), annual Industrial water consumption(y_2):

$$y_2 = 0.405 \cdot x - 788.4 \tag{3}$$

Then, we draw out the scatter plot and the fitting curve (as shown in Figure 5).

The predicted result turn out to be that 1.058805e+003 billion cubic meters of industrial water will be consumed.

Step4. Public water consumption:

Two forces act on the function: Particular year(x), annual public water consumption (y_3):

$$y_3 = 0.3539 \cdot x - 708.1 \tag{4}$$

Then, we draw out the scatter plot and the fitting curve (as shown in Figure 6).

The predicted result turn out to be that 3.307979e+002 billion cubic meters of public water will be consumed.

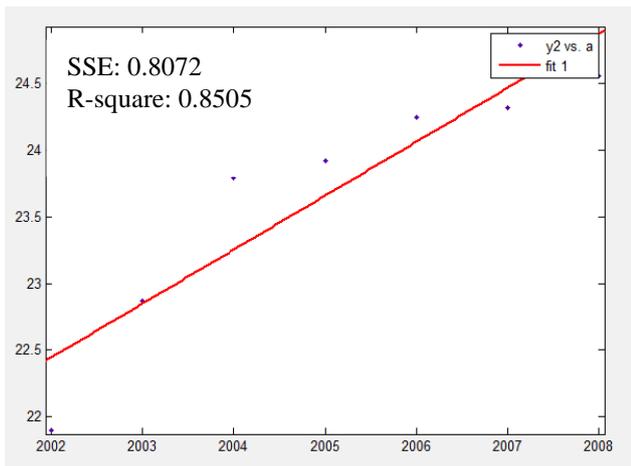


Fig.5: Industrial water consumption

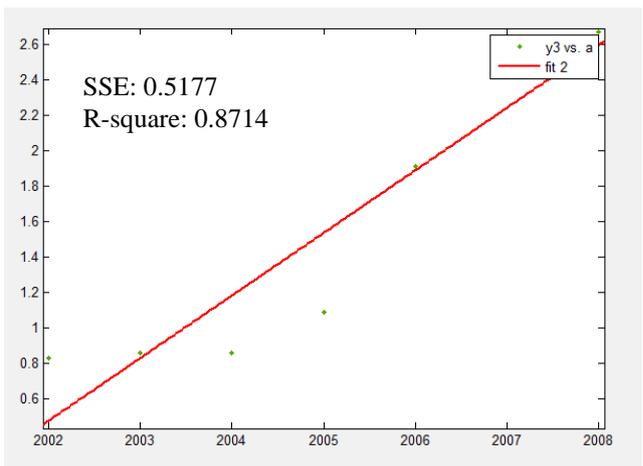


Fig. 6: Public water consumption

Step5. Total of the living, industrial and public water consumption is 1.6566586e+003.

Table 1. Water distribution

Year	Living water (m^3)	Industrial water (m^3)	Public water(m^3)	Total water (m^3)
2002	2.854	21.9	0.83	25.584
2003	2.894	22.87	0.86	26.624
2004	3.154	23.79	0.86	27.804
2005	3.348	23.92	1.09	28.358
2006	3.736	24.25	1.91	29.896
2007	3.865	24.32	2.53	30.715
2008	3.914	24.56	2.67	31.144
Summation	23.765	165.61	10.75	200.125

According to the table 1, we separately calculate the water consumption, and figure out the water distribution in Billings.

3. Sensitivity

Step1. Fitting of total amount:

The variance of the linear fitting's result is 0.3699, and the correlation coefficient is 0.9859; The variance of the power function's result is 0.4843, and the correlation coefficient is 0.9816. Through the fitting effect of the power function turns to be not very good, they preferably explain the relation between the variables.

Step2. Fitting of components:

1. Living water consumption: The variance of the linear fitting's result is 0.04853, and the correlation coefficient is 0.9599; The variance of the power function's result is 0.04843, and the correlation coefficient is 0.9600. And the fitting effect of the power function is better than linear fitting, they preferably explain the relation between the variables.

2. Industrial water consumption: The variance of the linear fitting's result is 0.8072, and the correlation coefficient is 0.8505; The variance of the power function's result is 0.8579, and the correlation coefficient is 0.8411. Through the fitting effect of the power function turns to be not very good, they preferably explain the relation between the variables.

3. Public water consumption: The variance of the linear fitting's result is 0.8072, and the correlation coefficient is 0.8505; The variance of the power function's result is 0.8579, and the correlation coefficient is 0.8411. The fitting effect of the power function fit well with the linear fitting, they preferably explain the relation between the variables.

4. Conclusion

The cost of water treatment of the original equipment is about 10 million. New equipment to deal with the cost of about 6 million, each time unit the advanced equipment can saves about 4 million. Due to the longer service life of the treatment equipment. We conclude that the budget for upgrading equipment can be accepted within 50 million.

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