Research into the Contamination of Drinking Water with Extensible Mind Mapping

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Keywords: Extenics, Drinking water pollution, Mind mapping.

Abstract. With the development of economy and industry, the demand for available water is increasing. However, the pollution of drinking water becomes a common phenomenon in urban. We all know it’s a huge threat to mankind. Therefore, it is essential to find out the best solution to this problem. According to our research, we found that the pollution of tap water mainly consists of water source pollution and secondary pollution. Through the theoretical knowledge of Extenics printed in a mind mapping that can reflect the whole procedure, we solved this problem well.

Introduction

According to the world health organization, 80% of the disease, 50% of cancer is related to contaminated water and 25 million children are sick to death in the world every year by drinking contaminated water[1]. It seems that the pollution of tap water becomes a common phenomenon in China. On March 4, 2015, Lanzhou tap water benzene exceeds bid badly, which affected the health of the public[2]. There are some researches into the solutions of contamination of drinking water[3]. However, no one yet solve this problem by a principle called Extenics[4]. Until now, people have successfully dealt with some problems with it[5]. Our team also has some research results about Extenics. For example, we have developed a service model based on Extenics[6]. Besides, we succeeded in making an android software about Extenics[7]. Hence, we try to analyze this problem by using Extenics in combination with mind mapping. The model is shown in Figure 1.

From Figure 1, we can clearly see that the original problem is divided into two subproblems and can divide it into three parts: goal base element, conditional base element and dependent functions. After changing the base elements, we need an Extensible transformation. Finally, we chooese the plan that is greatest to the superiority evaluation.

Procedures of Solving the Problem

Problem Modeling

According to relevant research, we found that the original problem can be divided into water pollution and secondary pollution. Therefore, we divide the original problem into two subproblems. We use surface water as the source of tap water to research, and the water should meet the third
standard of surface water quality standard (gb3838-2002)[8]. After consulting the standards above, we can classify the factors that affect water quality into two categories. One of them are called heavy metal ion that the conventional measure can’t remove. The another is the conventional indicators, like pH, which can met the standard quality of the drinking water by the routine process of waterworks.

Establishing two dependent functions to the base element attributes, we study the surface water of the coal area in the north of HuaiBei. By consulting the thesis[9], we fill in the heavy metal ions of the conditional base element with 3.00mg/L but the standard of normal value is 0~2.165mg/L. The "medium" represents the maximum processing capacity of waterworks, which requires deep processing to meet water standards. Therefore, we fill the "medium" in the conventional idicators of the conditional base element and set up base elements of the first kernel problem.

\[
L_1 = \begin{bmatrix}
\text{watsour} & \text{heavy metal content} \\
\text{conventional indicators} & \text{medium}
\end{bmatrix} \\
G_1 = \begin{bmatrix}
\text{watsour} & \text{heavy metal content} \\
\text{conventional indicators} & \text{greater than medium}
\end{bmatrix}
\]

For base element attribute heavy metal content, we set up an elementary dependent function \(k_1(x)\). With the help of the Extenics formulas, we can calculate the dependent function value \(k_1(3.00)<0\) and we know that it is a contradictory problem. In addition to, we also need to establish a discrete dependent functions \(k_2(x)=1\) shown in the following.

\[
k_2 = \begin{cases}
\text{very few} & 2 \\
\text{little} & 1 \\
\text{medium} & -1 \\
\text{severe} & -2
\end{cases}
\]

We also divide the second kernel problem like above problem. By consulting some reports, base element attributes are selected including coproduct, the outside pollution and water supply network. The coproduct, a harmful substance, will produce when chlorine is used in water plants. According to the standards for drinking water(gb5749-2006)[10], we found that, the coproduct can’t exceed 0.47mg/L. Consequently, we set the coproduct of the goal base elements to 0.47. However, since the process of most water plants in China is backward, the content is 3.00mg/L. As for the outside pollution, due to the long use of the water pipe network in China and there is no regular replacement, the pipes is very easy to break. The outside pollution can seep into the pipe newwork. Besides, the pollution also comes from reservoirs that haven’t been cleaned. At the same time, because of the factors of water, it can cause long-term erosion of the pipes. Considering these factors, we fill the outside pollution and water supply network with little and abnormal in the condition base element. The base elements and dependent functions are shown as follows.

\[
L_2 = \begin{bmatrix}
\text{sepo} & \text{coproduct} & 0.61 \\
\text{the outside pollution} & \text{little}
\end{bmatrix}
\]

\[
G_2 = \begin{bmatrix}
\text{sepo} & \text{coproduct} \\
\text{the outside pollution} & \text{none} \\
\text{water supply network} & \text{normal}
\end{bmatrix}
\]

For base element attribute coproduct we set up an elementary dependent function \(k_3(x)\). We can calulate the dependent function value \(k_3(0.61)<0\), knowing that this is an incompatible problem. We set up discrete dependent functions \(k_4(x)\) and \(k_5(x)\) for them shown in the following.

\[
k_4 = \begin{cases}
\text{none} & 1 \\
\text{little} & -1 \\
\text{medium} & -2
\end{cases}
\]

\[
k_5 = \begin{cases}
\text{normal} & 1 \\
\text{abnormal} & -1
\end{cases}
\]
Extensible Analysis

We showed four base elements including L1.a for planting Wetland plant, L1.b for using microbial. Their comprehensive dependent function values are 1.88 and 1.88 respectively. They are listed as follows.

\[
L1.a = \begin{bmatrix}
\text{watsour} & \text{heavy metal content} & 2.165 \\
\text{conventional indicators} & \text{little} \\
\end{bmatrix}
\]

\[
L1.b = \begin{bmatrix}
\text{watsour} & \text{heavy metal content} & 2.165 \\
\text{conventional indicators} & \text{little} \\
\end{bmatrix}
\]

Plant Wetland plant: Some poisonous substances can be converted into non-toxic substances through plants. But it will increase the retention of water.

Using microbial: By looking at research on the use of microorganisms to solve pollution, we think that this is feasible. We can put in the appropriate amount of microorganisms that can handle the pollution.

For the second kernel problem, there are 3 base elements including L2.a for upgrading technology, L2.b for replacing pipes and L2.c for cleaning regularly. Their comprehensive dependent function values are 0, 1.86 and -2.66 respectively.

\[
L2.a = \begin{bmatrix}
\text{sep} & \text{coproduct} & 0 \sim 0.47 \\
\text{the outside pollution} & \text{little} \\
\text{water supply network} & \text{abnormal} \\
\end{bmatrix}
\]

\[
L2.b = \begin{bmatrix}
\text{sep} & \text{coproduct} & 0.61 \\
\text{the outside pollution} & \text{none} \\
\text{water supply network} & \text{normal} \\
\end{bmatrix}
\]

\[
L2.c = \begin{bmatrix}
\text{sep} & \text{coproduct} & 0.61 \\
\text{the outside pollution} & \text{little} \\
\text{water supply network} & \text{abnormal} \\
\end{bmatrix}
\]

Upgrading technology: At present, because of using chlorine gas, drinking water have hidden danger. If the technology is upgraded, the content of coproduct can be reduced effectively.

Replacing pipe and Clearing regularly: Replacing the pipe can effectively reduce the phenomenon of water pipe rupture. Because secondary water systems are prone to scaling, regular cleaning is able to solve the pollution.

Water purification machines: We have a machine that can clean water at the end of the pipe. Although it can play a certain role in purification, it can not solve the problem fundamentally.

Extensible Transformation

By analyzing the basic elements above, we exclude some extended elements whose comprehensive dependent function value are less than 0. For the first kernel problems, we eliminate none and for the second kernel problems, we will remove L3.c.

In the first kernel issue, the selected scheme can be expanded by extension L1.b.1 for Using machines to reduce the time of water stay. Comparing the effects of the different strains, we make L1.c.1 for aerobic bacteria and L1.c.2 for Using anaerobic bacteria. Their primitive properties are shown above, and the values of the composite correlation functions are 2.12, 2.86, and 3.45.

\[
L1.a.1 = \begin{bmatrix}
\text{watsour} & \text{heavy metal content} & 2.165 \\
\text{conventional indicators} & \text{little} \\
\end{bmatrix}
\]

\[
L1.b.1 = \begin{bmatrix}
\text{watsour} & \text{heavy metal content} & 2.11 \\
\text{conventional indicators} & \text{little} \\
\end{bmatrix}
\]

In the second kernel issue, selected scheme can be expanded by extension L2.a.1 for Using ozone to sterilize, L2.a.2 for Using sodium hypochlorite to sterilize, L2.b.1 for Using the stainless steel, L2.b.2 for Using copper pipe. Their primitive properties are shown above, and the values of the composite correlation functions are 1.86, 3.44, 2.88 and 3.68.

\[
L2.a.1 = \begin{bmatrix}
\text{sep} & \text{coproduct} & 0.35 \\
\text{the outside pollution} & \text{little} \\
\text{water supply network} & \text{abnormal} \\
\end{bmatrix}
\]

\[
L2.a.2 = \begin{bmatrix}
\text{sep} & \text{coproduct} & 0 \\
\text{the outside pollution} & \text{little} \\
\text{water supply network} & \text{abnormal} \\
\end{bmatrix}
\]
Superiority Evaluation

In the transformation of Extenics above, we chose the two kernel problems with the most advantageous solution. Therefore, we choose the L1.b.2 for the first subproblems and choose L2.a.2 and L2.b.2 for the second subproblem simultaneously. Their dependent function values are listed as follows.

<table>
<thead>
<tr>
<th>$L_2.b.1$</th>
<th>$L_2.b.2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>sepo</td>
<td>coproduct</td>
</tr>
<tr>
<td>the outside pollution</td>
<td>none</td>
</tr>
<tr>
<td>water supply network</td>
<td>normal</td>
</tr>
<tr>
<td>sepo</td>
<td>coproduct</td>
</tr>
<tr>
<td>the outside pollution</td>
<td>none</td>
</tr>
<tr>
<td>water supply network</td>
<td>normal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$H_1 = L_1.b.2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$watsour$</td>
</tr>
<tr>
<td>conventional indicators</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$H_2 = L_2.a.2 &amp; L_2.b.2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>sepo</td>
</tr>
<tr>
<td>the outside pollution</td>
</tr>
<tr>
<td>water supply network</td>
</tr>
</tbody>
</table>

Conclusion and Future Work

We draw a conclusion that using microorganisms and the planting wetland plants, the upgrading technology, the replacing pipes and the clearing regularly. The whole procedure of solving the problem is shown in Figure 2. Besides, we are already preparing to develop a software that realize the mind mapping function of Extenics and planning to explore human’s whole procedure of solving the problem with Extenics.

Figure 2. Whole procedure of innovation mind.

Acknowledgements

The research is supported by Guangdong Provincial Science and Technology Project (2014A040402010) and Guangdong Province Innovation and Entrepreneurship Training Program for College Students (201710566036).
Rui Fan*: Rui Fan(1958–), male, Professor, specializes in Software Engineering, self-adaptive software formal modeling, Extenics Engineering etc.

References


[8] Surface water environment quality standard (GB3838-2002))
