Gis advantages and Water Quality Effects and problems In Maintenance Management of Long-Line Water Distribution Systems

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Abstract: In the last two decades by the growth of computer industry, the methods of collecting, processing and storage of information and statistics used to show and simulate the future status which is important and essential in the management of water distribution systems. Nowadays, water distribution systems analysis methods as an impressive technique introducing hydraulic behavior concept, development and operation designs assessment, and generally overcoming lack of information have been accepted. This article is to discuss about the factors causing low quality of water in water distribution systems and most of the factors considered are in the aspects regarding to hydraulic oscillation, quality (water age), maintenance management of distribution systems with consumption pattern, long-line networks and water supply sources problems in a certain area, as well as problems arisen from either quality or quantity or GIS services. Besides, relevant tools to reduce such problems are discussed.

Key words: water age, GIS, Maintenance Manager, Water Quality, water quantity, water in the distribution system long lines.

INTRODUCTION

Creating the qualitative water designs in urban water systems due to useful and creative properties are the most important fundamental programs in new operations and causes the water systems to improve hygienically; therefore, they deserve to be always at the top. Water qualitative control activities establishment not only does not cause the designs and operations to size or to be restricted but also is known as a suitable tool in identifying those parameters involved in water pollution. In other words, these control activities can be defined as a process in which prevents the costly problems and other harmful effects imposed on future society economics. Christelle Legay, (2009) In general, the water qualitative control activities objective is to help water design and operative systems enhance water quality in order to deliver water in a higher and more satisfying way to society consumers. (M.M.ARAL, 1996) Through water qualitative control we are capable to identify, predict, assess the impressive or harmful outcomes(Kátia Coutinho Barbosa ) Since there are various destructive causing parameters, the qualitative models and Geographic Information system (GIS) can contribute to select the best and the most appropriate pathways to solve the water qualitative difficulties. Furthermore, through identificati and continuous oriented analysis, qualitative parameters and pollution source and location are identified by means of models and GIS. (Aral, 1996) The purpose of water transmitting and treatment by water distribution system is to provide high quality drinking water so that the customer will be satisfied from water quality and water quantity; hence, no danger will threaten the customer’s health. In all articles or conferences held, the factors that cause water quality loss and water distribution systems are discussed and some pilot experiments and studies in different places in which the results are similar and the cause is unknown are carried out. If the presented method is cross sectional, obviously every region has had its own problems. Most difficulties have been after the refinery, but this paper is aimed on understanding these problems which are available that how these problems can be reduced. In this regard (Russell E, 2009), GIS can help us a lot, especially in the exact sources of drinking water supply and methods that allow designers to reduce the water age and hence management and administration in the maintenance of the facilities will be easier for employers (Russell E, 2009) Distribution systems in which the lines are long require more quality and quantity maintenance and management by the contribution of GIS since GIS science can change a great system into several small systems.

MATERIALS AND METHODS

Geographic Information System(GIS):

Although normally the concept of productivity is associated with savings in terms of human resources application, technical technology, and cost saving, most of the designer imagine the productivity as the most
efficient procedures taken to be based on maximum utilization of existing resources. There is no doubt that this eulogy is not necessary but also not complete. By the application and use of some new tools of technology many procedures can modify or eliminate the current faults or the following extra work. (Yuefeng F, 2008) These applications of GIS can create the ways to cut costs and reduce resources to achieve a goal including advanced tools that can be used and organize the information and can be applied in various industries including water and sewage companies. As experience has presented, GIS can be used as a proper basis in establishing all infrastructures and adjusting various activities in an effective and dynamic discipline. In GIS, there are several software that can be applied in water quality evaluation in water distribution systems such as following:

* NRG (Norfolk Ram Group): This software is developed. The software is for minimizing waste and water management for high quality distribution systems.

* Arcview: This software is used for organization, repairing, maintenance, and analysis in water distribution systems.

* SCADA: that is very useful to retrieve and identify water quality control in a short-period case.

Perhaps, the name GIS has conceptually no relevance to water quality in the distribution systems. But GIS can contribute very much to solve water quality and quantity problems existing today.

**Water quality in distribution systems:**

When water exits the water treatment plant, its quality level is satisfying, but in long line distribution system particularly, it will possess some quality and quantity problems. Many factors can be effective. One of the (EPA/625/R-92/001 June 1992) problems that is very important for distribution system water quality is water age, so water age is the cause of two major factors in water quality downfall:

1. I-Chlorine loss in between pipe wall and water (kw)
2. II-Chlorine spoiling due to water bulk ineractions (kb) The distributed water will face qualitative problems, therefore, water age include all factors that cause the decadence of water quality. If the decadence of water quality is reviewed with respect to water age, the factors can be stated (Licia Guzzella, 2006 and Markku Lehtola, 2002) as follows:

2-1 _ Chemical problems: byproducts, disinfectant material decadence, corrosion, taste and odour;
2-2 _ Biological problems: byproducts, nitrogen, bacterial regrowth, taste and odour;
2-3 _ Physical problems: temperature increase, sedimentation in pipe, color.

All of these factors are due to water age in the water distribution system (Robert M. Clark, 1999 and EPA.AWWA, 2002), but those factors belonging to long-line distribution system are much more important and complicated.

**Quantity in the distribution networks (effects of quantity on quality):**

Perhaps this paper has only considered the water quality as an objective, but many factors will be quantity that can influence the water quality. In this section, we will more talk about pressure and speed and consumption patterns. Relationship between velocity and pressure and their contribution to water quality will be investigated in these two cases;

**A- Hydraulic. B- consumption pattern:**

**A-Hydraulic:**

Hydraulic factors that can influence on the water quality decadence. (EPA/625/R-92/001 June 1992) the systems that have long line, Pressure and speed control on these networks would be extremely difficult. Because the pressure and velocity are not feasible or desirable. Where the pressure is high and the rate of speed in the network converges to zero. In other words, pressure and velocity are reversely proportional relative to each other. So alterations result in decadence in water quality. (Janis Rubulis, 2007 and Licia Guzzella, 2006) So changes in pressure or flow of water will cause the increase in water turbidity, iron and biofilm compaction in water distribution network System and due to pressure shock and separation of sedimeted biofilm from the pipe wall and eventually cause the microorganism population to increase in water and make possible leakage, crack, or rupture in the overpressure points. The high pressure makes a centrifugal force that suspended particles to be deposited on the pipe wall and sedimentation leading to biofilm formation, also in the systems that have long residence time and water is in static form and not in circulation (Robert M. Clark, 1999) form, a phenomenon is also made that is called Nitrification in which spoils the disinfectant materials. The other cause made in low flow streams could be the outbreak of tuberculosis. Recycle streams can make the microbes aggregate and distribute in pipeline where end dead systems exist. Besides, the locations in which the water flow rate is high in the network, the decadence of disinfectant materials is much higher.

**B- Consumption Pattern:**

Normally in water supply system projects, designs are carried out for 20 to 30 future years. (EPA. AWWA, 2002) Water production, water delivery, designed pipe diameter and vessel volume would be for the end of design; therefore, the predetermined amount of water would be higher than that of the consumption. This fact
leads to an increase in water residence time in water distribution system. However, the difference between production and consumption values reduces by passing the time. Hence, (M.M.ARAL, 1996) it is necessary to access comprehensive information concerning society population, consumption pattern and the typical utilization (e.g. commercial, residential or educational) from different regions since the production value may be steady whereas the consumption value is varying during the whole day. The production and consumption difference might be stored some in storage tanks or be available in a static form within water distribution systems. This effect makes the water age increase in water installations which leads to a fall in water quality. Therefore, GIS and modeling softwares can help find resources, and real consumption pattern as well as decrease water age, water volume in storage tanks and pressure or speed fluctuations in water distribution systems.

**Water quality maintenance management in water distribution systems:**

The resources of water are very limited and many of them are even unknown. One of the factors helpful for the water distribution systems is water quality maintenance management in such systems by means of GIS software and the models associated with GIS. Water distribution systems are the assets of relevant manufacturing companies in which are specialized in optimization aspect and continuous usage of such assets that should be protected through highest effort as much as possible; In water quality management in water distribution network systems, the causes and effects impressive on distribution systems should be defined in order to preserve water quality. (Kátia Coutinho Barbosa and Christelle Legay, 2009) The main duty attributed to water quality maintenance management in water distribution systems is the public health protection. This quality and its respective preservation should be carried out based on legacies and under governmental supervision, respectively. Therefore, at first polluted resources must be identified and then urgent modifying actions must be implemented. Moreover, prevention of wells and sources pollution and reparation and maintenance of them, maintenance of distribution system pipes, repairing, (ALAIN KERNEYS, 1999) operational and flash performance in the main program and other suitable performances, inspection and maintenance of vessels, the least pressure in the network system as well as water quality should be controlled. In fact, the properly-protected and controlled water distribution system are less subjected to water quality problems. In water distribution and network systems, any problem made must promptly be identified and removed. To remove these difficulties, providing precise information for the public consumers’ health protection is inevitable such that the problem has to be solved in a short time period before consumer discovers or complains the existing problem.

**RESULT AND DISCUSSION**

Nowadays, (E. Delahaye, 1999) applying the methods for scientific design of urban water distribution systems are playing a clear role in providing appropriate services to customers. If Companies responsible for supplying and distributing water are not familiar with these techniques and their applications with respect to distribution system development and increase of the customer demand for better services, face to many problems forever. In the present world of progress and development, operation, reparation and maintenance gradually is being replaced by the prediction and prevention-based operations. (Christelle Legay, 2009) In order to achieve this purpose, applying the following tools like GIS is required;

**Hydraulic:**

As it has already been mentioned, one of the most important factors for water quality and water age in water distribution network systems is hydraulic. (M.M.ARAL, 1996) These primary factors are based on all of the water quality problems in the distribution systems. All of these factors are summarized in two parts, but consumption pattern in the distribution network systems should not be forgotten as well. Hydraulic and water age effects are more associated with long-lines systems. One of the factors (A.O. Al-Jasser, 2006) that cause deterioration in the quality of urban water distribution networks is microorganism growth in such networks. According to researches done, the microorganism growth, corrosion and lost of disinfectants in networks is the product of long water age and pressure and speed fluctuations. Another problem is the type of disinfectant. Chlorine is the only suitable material for network distribution systems due to its high persistence in distribution network systems; however, it also has some disadvantages. Chlorine is not able to kill all the bacteria within the system; furthermore, since Chlorine molecules are large (Delvin E. 2006), they can not penetrate through gelatinous biofilms whereas Chloramine can diffuse to gelatinous substance owed to its smaller molecules; however, its killing power of bacteria is less and also has higher durability. Chloramine materials can be combined with organic material in water and make carcinogenic by product. Direct Chlorine injection in distribution network systems is dangerous. (EPA/625/R-92/001 June 1992) In this case the chlorine solution is in the solution form, therefore, its disinfection would be less. Another factor is the water transparency which will be lost due to high water age in water distribution network systems. Considering the above factors, high
water age will deteriorate the water quality in water distribution network systems and we can not expect a minimum chlorine in the network at the end of pipeline, but the quantitative factors have proportional relation to water quality in water distribution systems. (EPA/625/R-92/001 June 1992) Hydraulic (Pressure and speed) always cause problems concerning with water quality in long-line water distribution network systems because the minimum pressure exists at the end of such long-line networks. Hence, it is necessary to produce high pressure system which is difficult. Speed and pressure should possess some value; because the high pressure system will reduce the speed. Low speed in the system results in sedimentation of suspended substances on the pipe wall. On the other hand, if the water flow mode in water distribution systems is turbulent meaning that such systems have high speed, the bacteria will agglomerate, hence the economical speed is required (Christelle Legay, 2009 and E. Delahaye, 1999). Therefore, GIS and qualitative and quantitative models or other software can help solve a lot of difficulties made. (E. Delahaye, 1999) By the help of GIS and using suitable models we can find the proper resources and achieve to desirable speed and pressure and eventually provide qualified water to the customer. One of the important qualitative factors is consumption pattern in distribution systems. The accurate consumption value is one of the basic and fundamental factors. (Markku Lehtola., 2002) If the pattern is not defined properly, water quantitative and qualitative problems occur in water distribution network systems and water age increases since the production is more than the required consumption. Many designers when start to design, consider only quantitative problems such as pressure and speed while qualitative problems which are important as well like residual Chlorine, microorganism growth, water age, pipe materials, pipe crossing barriers, groundwater layers level, resources quality and etc. which are effective in water quality are not considered. Therefore, it is necessary that GIS and environmental experts cooperate with water hydraulic designers. In this case, some questions are asked as in the following:

*-, Whether the existing water production is base on today? If pipe size is intended for the future, then the network encounters hydraulic problems. (i.e. there is head loss in the distribution system "low pressure and high speed")

*-, Whether water production is for the future? Therefore, the network is suffered from quality issues (water age) meaning that the rate of production is higher than that of consumption. In both of the above cases, the network is not economical and it is dealing with quantitative and qualitative difficulties. GIS and modeling software can help water distribution system designers design the networks which both the qualitative and quantitative parameters have been taken into account.

**Maintenance management of water quality in the distribution system:**

Maintenance management of water quality is one of the important factors that can be effective for water quality enhancement in water distribution systems. If water quality maintenance and management does not exist, the company properties such as pipes, joints and etc. face many problems. It is beneficial when the problems are found, identified and solved by applying (Yuefeng F, 2008) GIS and modeling softwares. The management of large and long-line networks and those in which are supplied by just one resource, has more difficult control and higher risks. For instance, when water treatment plant electricity is cut or the network is subjected to qualitative and quantitative problems, numerous people face water cut problems; hence (Kátia Coutinho Barbosa and Shannon L. Isovitsch) GIS can find several water suppliers and make it possible to have smaller water treatment plants as well as smaller distribution systems and higher water quality through more facile management and less risks.

Considering all the things about water quality and distribution network systems, it is concluded that most water quality problems in water age, distribution of water, hydraulic problems, consumption patterns will be in water quality maintenance management systems and distribution networks. These problems are more for the regions that water is supplied from just one supplier and have long-line networks. GIS and modeling softwares can help us find different water resources and build small water treatment plants to lower the existing problems. Applying GIS in water quality systems include advantages that are followed as below:

1. Less water age in the water distribution network systems;
2. Less water pressure and speed fluctuations as well as less vessel volume changes;
3. Better water distribution systems control;
4. Less danger of risk;
5. Easier production and consumption rate control;
6. Less leakage rate and lost water;
7. Better water quality
8. Higher water quality maintenance management water distribution network systems;
9. Less energy costs for pumping stations;
10. Less use of chlorine in the water distribution systems;
11. Less decadence rate of chlorine in networks;
12. Appropriate amount of residual chlorine, pressure and speed in water distribution systems;
13. Less danger trihalomethane (THMS) and haloacetic (HAAS)

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