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Research Article

Evaluation of Drinking Water Network Chlorination Performance for Ondokuzmayıs District Using MİKE URBAN

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Abstract

The quality of water must be suitable for the process until the last subscriber is treated from drinking water in the drinking water network. The chlorination process is an important process in order to keep certain parameters of water quality at certain intervals. The chlorination process must be managed in accordance with the drinking water demand. The operation of a drinking water network without the right chlorination strategy increases the cost of the water as well as the healthy transportation of the water to the end user point. The aim of this study is to create maps of chlorination according to seasons of Ondokuzmayıs district of Samsun and ensure implementation of correctly strategy. After collecting samples at predetermined time and points according to seasons at Ondokuzmayıs district, chlorine values were determined in laboratory. The average chlorine results measured at five points were found to be 1.2158 mg L^{-1}. After the determination of quality values of chlorine was identified, locations at MİKE URBAN water supply system geographic information system are defined according to each season. Value of chlorine in the entire network system Ondokuzmayıs district has been identified. By obtaining this data, city chlorination maps have been derived. At the maps, where and why chlorine value is low or high have been determined, and that must be followed correctly strategy has been created.

Keywords: chlorination, MİKE URBAN, modelling, water quality.

Ondokuzmayıs İlçesi İçme Suyu Şebekesi Klorlama Performansının MIKE URBAN İle Değerlendirilmesi

Öz

İçme suyu şebekesindeki içme suyunun arıtılmasından son aboneye ulaşıncaya kadar ki süreçte suyun kalitesinin uygun olması gerekmektedir. Su kalitesinin bazı parametrelerini belirli aralıklarda tutulabilmesi için klorlama prosesi önemli bir prosestir. Klorlama prosesi, içme suyu talebine göre uygun olarak yönetilmesi gerekmektedir. Bir içme suyu şebekesinin doğru klorlama stratejisi yapılmadan işletilmesi hem maliyetini artırmaktadır, hem de son kullanıcı noktasına kadar suyun sağlıklı bir şekilde ulaştırılabilmesi sağlanamamaktadır.

Bu çalışmanın amacı Samsun Ondokuzmayıs ilçesinin mevsimlere göre klorlama haritalarının oluşturulması ve doğru stratejilerin uygulanmasının sağlanmasıdır. Ondokuzmayıs ilçesinde mevsimlere göre önceden belirlenmiş zaman ve noktalarda numuneler alındıktan sonar laboratuvarda klor değerleri belirlenmiştir. Beş noktada ölçülen klor değerleri ortalama 1,2158 mg/l olarak bulundu. Bulunan klor değerleri ,MİKE URBAN'da içme suyu şebekesi coğrafi bilgi sisteminde yerleri tespit edilerek her mevsime ayrı ayrı tanımlanmıştır. Bu çalışmalarla Ondokuzmayıs ilçesindeki şebeke sisteminin tamamında klor değerleri belirlenmiştir. Bu verilerle

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birlikte mevsimlere göre şehrin klorlama haritaları oluşturulmuştur. Bu haritalarda klor değerlerinin nerede neden düşük veya yüksek olduğu tespit edilmiş ve izlenilmesi gereken strateji oluşturulmuştur.

Anahtar Kelimeler: Klorlama, MIKE URBAN, modelleme, su kalitesi.

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1. Introduction

Chlorine, an efficient, inexpensive and stable disinfectant, has been in continuous use for water disinfection for a long time. Chlorine in the network disappears due to reactions with ammonia, organic compounds, deposits on pipes and the pipes themselves (Zhang et al.,1992). Chlorine containing disinfectants are effective for most known pathogenic microorganisms and completely destroys or prevents from being reproduced them. Chlorine takes control of biological growth, block formation of living things can clog and cause malfunction pipes and devices or can develop in storages. Chlorine provides chemical control, disintegrate hydrogen sulphide, ammonia and other nitrogen compounds that may be present in water (Oğur et al.,2004). When chlorinated water enters the distribution system, chlorine residual tends to dissipate. Three factors that frequently influence chlorine consumption are: (1) reactions with organic and inorganic chemicals in the bulk aqueous phase; (2) reactions with biofilm at the pipe wall; and (3) consumption by the corrosion process. (Munavalli et.al.,2005). Chlorine given to network decreases with the reaction of various organic and inorganic substances in water. Therefore, chlorine consumption rate is directly related to drinking water quality (Muhammetoğlu et al.,2011). Water quality models that simulate chlorine decay are valuable tools for the management of chlorine residual. Such models are currently used for dosage optimization, chlorination facilities siting and prediction of critical locations where chlorine may decay to ineffective levels (Monteiro et al.,2014). MIKE URBAN is developed by the Danish Hydraulic Institute (DHI) which is an integration of mathematical modelling procedures developed for hydrologic, hydraulic and water quality simulations. In the research study, the time-area method was selected as the hydrologic modelling approach due to its simplicity, but at the same time the ability to provide relatively accurate results (Liu et al.,2010). The important parameter for MIKE URBAN model selection is usability of simulation engine, workflow, flexibility and integration of GIS (geographic information system) as well as physical robustness, productivity and steady urban water modelling software (URL-1). The aim of this study is to determine the use of chlorine in the drinking water network of Ondokuzmayıs districts of Samsun according to the seasons and to implement the correct strategies. For this, MIKE URBAN modelling program is used in modelling. Similar disinfection and modelling studies are included in the literature (Paraskevas et al.,2007;Günal and Kösen,2015).

2. Materials and Methods

2.1 Study Area-Ondokuzmayıs District in Samsun

Sampling activities were carried out in drinking water network of Ondokuzmayis district in Samsun province. Ondokuzmayis district is 33 kilometers away from Samsun, located on Samsun - Sinop highway. The height to water of the district center located at eastern end of Kızılırmak river bring delta lowland is 10 meters. The territory to north of district center constitutes a part of lowland formed by Kızılırmak. This area has some of fish lakes. The district is surrounded by Samsun at east, Bafra at west, Black Sea at north, Samsun and Bafra at south. The highest place is southern hill where Nebiyan forests are located (URL-2).

2.2 Sampling of Samples

Samples were collected from five different points in August 2013 in summer, October 2013 in autumn, December 2013 in winter and March 2014 in spring. Names of sampling points selected for analysis are tabulated in Table 1. Five different geographical locations have been identified. In Figure 1, points in each region and names of points are shown as schematically.

Table 1. Sampling points at Ondokuzmayis city

S1	Main Reservoir
S2	19 Mayıs State Hospital
S3	Aşık Kutlu Education Center
S4	Tekel İsmail Çolak Primary
S5	Vali Şinasi Kuş Park

S1 point is the biggest water reservoir provides general water distribution to network. S2 is state hospital in district where population of the district is more than population density. S3 is an education center located at a distance from center and away from lower regions. S4 point is a primary school near the city's tobacco factory. S5 point is a park near sea level. Sampling is usually complete mornings between 10 and 12 hours. At all points, samples were collected from a tap near street. Before samples were collected tap was opened for 5 minutes to ensure that public came directly from water mains and that building wasn't from plumbing system. Immediately after samples were collected, they were moved to laboratory for analysis at the same day. Chlorination analysis was measured by T70/T70+ UV-VIS Spectrophotometers device in laboratory.

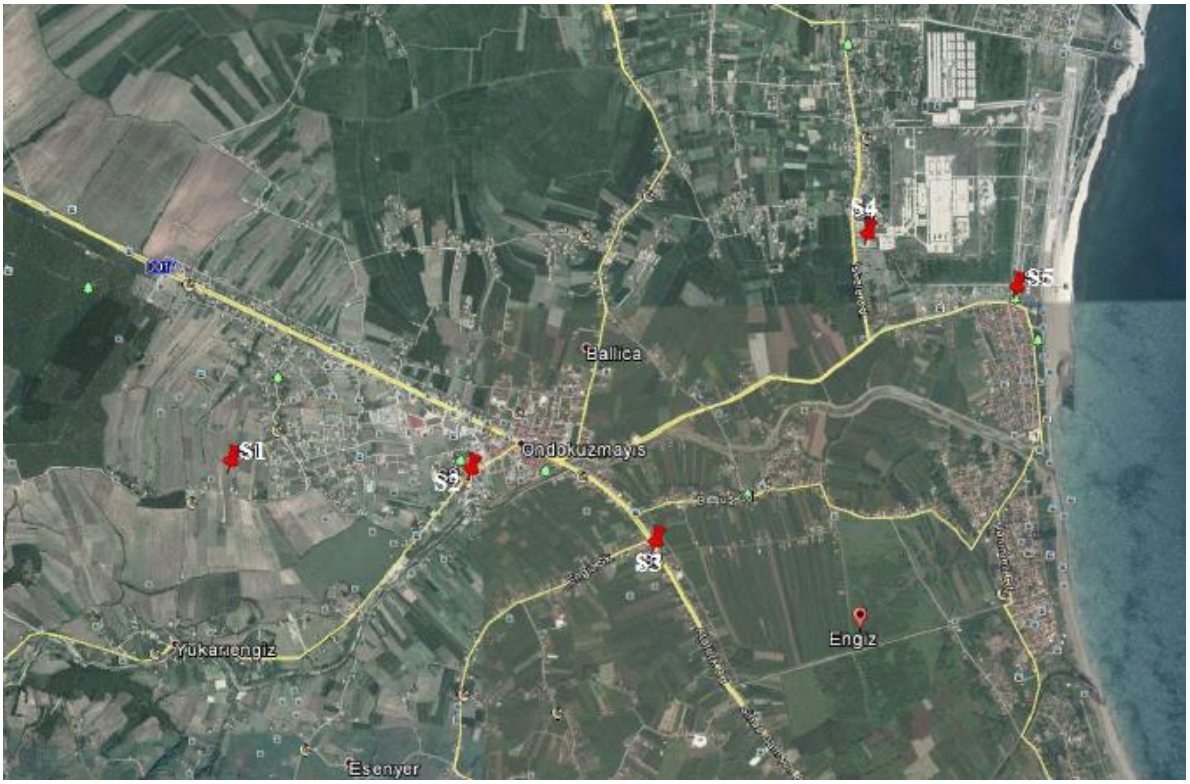

Figure 1. Sampling points at Ondokuzmayıs District

2.3 Modelling Application

Firstly in MIKE URBAN software such as diameters, materials, altitude according to sea of all pipes, intersection points, reservoirs and pumping stations, reservoir volumes, pump values of Ondokuzmayis district were entered. Once hydraulic infrastructure of network has been completed, it becomes suitable for modelling. Modelling studies have been carried out on chlorine values every season separately. Certain roughness coefficients have to be used in modelling studies. These coefficients can be obtained in two different ways, locally and globally. In this study, roughness coefficient of pipe surface was taken as -0,4. There are 5 points in model of drinking water network that we introduce to measurement and modelling. Calibration bubbles are created as shown in Figure 2 to calibrate model of these points. In these balloons, M.V. shows modelling analysis result values, A.V. shows actual analysis result values.

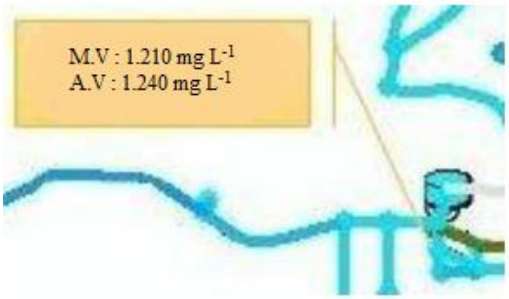

Figure 2. Calibration bubbles comparing modelling - analysis values

Concentration of chlorine in drinking water varies from 0 to 1 mg L^{-1} to light blue to dark blue. When chlorine concentration is 1-5 mg L^{-1}, it changes from light green to dark green tones. Chlorine concentrations is in range of 5-6 mg L^{-1} in yellow color, red color turns from yellow in range of 6-10 and 10 mg L^{-1} and above values will be black tone (Ulutas, 2015).

3. Results and Discussion

Samples were collected at the site and analyzed in laboratory. After analysis, results were determined and entered into the modelling software, modelling results were obtained.

3.1 Laboratory Results

Analysis results are given in Table 2. Units of all results in Table 2 are mg L^{-1}..

Table 2. Chlorine analysis results of Ondokuzmayıs District

	Summer	Autumn	Winter	Spring	Ave.	St. Deviation
	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	
S1	1.240	0.514	0.130	0.223	0.527	0.503
S2	1.238	1.587	1.048	1.302	1.294	0.220
S3	4.598	0.472	0.243	0.133	1.362	2.160
S4	2.207	0.652	0.288	0.090	0.809	0.960
S5	2.101	5.891	0.141	0.214	2.087	2.690

According to results of analysis, increase in chlorination values and increase in regional differences are due to increase of chlorination activity in water together with increase of usage of drinking water in summer months. In other months, results of sampled points are close to each other, indicating that chlorination activity is lower than summer. During fall season, the point where chlorine value is high due to the lowest point as level between measuring points of S5 point is hitting surface. The level of chlorination in city is determined by taking community health center at S2 point as a reference.

3.2 Modelling Predictions

Modelling predictions were obtained for separately each season after hydraulics infrastructure of Ondokuzmayis district was prepared.

Summer - 2013

Modelling of summer Cl^- values of drinking water network formed from obtained analysis results is provided at Figure *3*. According to results of this modelling, difference of Cl^- values according to location of network is multiplied. Main reason for this is increase in amount of Cl^- given to drinking water network with increase in summer water consumption. In addition, chlorine is present in entire city drinking water network, even if it is less especially at high altitudes. This indicates that entire drinking water network is disinfected.

Figure 3. Chlorine modelling predictions of Ondokuzmayis in summer season of 2013

Autumn - 2013

Chlorine model of fall season of drinking water network formed from obtained analysis results is given in Figure 4 Chlorine values are adjusted with reference to state hospital in the city center. Therefore, there is around 1 mg L^{-1} of chlorine value around state hospital. It has a chlorine value to keep quality of drinking water at an average level until less to sea level.

Figure 4. Chlorine modelling predictions of Ondokuzmayis in autumn season of 2013

Winter - 2013

Chlorine model of winter season of drinking water network formed from obtained analysis results is given in Figure 5. According to these results, there is around 1 mg L^{-1} of chlorine value around state hospital. Chlorine is present in entire city drinking water network, even if it is low in elevated places.

Figure 5. Chlorine modelling predictions of Ondokuzmayis in winter season of 2013

Spring - 2014

Cl^- model of spring season of drinking water network formed from obtained analysis results is given at Figure 6. According to results of modelling, near 1 mg L^{-1} Cl^- is in network close to city center. Elsewhere lower levels of chlorine have been found.

Figure 6. Chlorine modelling predictions of Ondokuzmayis in spring season of 2014

4. CONCLUSION

Evaluation and suggestions were made after modelling predictions were obtained.

1. Instead of high-level chlorination at a few points, mean-level chlorination should be preferred at many points. Intermediate chlorination stations should be installed in areas that aren't at low elevation levels in drinking water network and in areas remote from main storage zone. With establishment of intermediate chlorination stations chlorination levels will decrease. Water containing high chlorine will have negative effects on health of human beings and other living beings when used as drinking water. Concentration of chlorine and organic-inorganic matter increases, concentration of trihalomethanes increases. Trihalomethanes are substances that can cause carcinogenic effects.

2. In summer, fall and spring seasons, concentration of chlorine suddenly arrives at colors that correspond to high values, as can be understood from intervals in color palettes near sea as a result of analysis of model. Low slaughter didn't results in high quotas but chlorine influenced all of settlement at sea level. Reducing chlorine level in network will be accompanied by a reduction in level of chlorine added to drinking water as well as an increase in number of chlorination points and construction of intermediate chlorination stations at suitable locations.

3. High flow chlorination process at lower points increases cost of chlorination due to chlorine flying. Average flow chlorination from a many of points will be an investment that also saves operating costs. Therefore, number of chlorination points should be increased and chlorination doses should be reduced in parallel with increase of number.

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