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Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment

Spatio-Temporal Assessment of Chlorine Residual in the Water Distribution System of Dhaka City

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Background of the Study

Nowadays, majority of the people of Dhaka City in Bangladesh are completely depending on supplying water from production tube wells (PTWs) under the Dhaka Water Supply and Sewerage Authority (DWASA) for household potable water use for ensuring the water safety. However, proper understanding, characterization and prediction of water quality behavior in the drinking water distribution system are critical to ensure to meet regulatory requirements and customer-oriented expectations.

Objectives of the Study

The main objectives of the study are as follows:

1. Assessment of the effectiveness of the current chlorination system.
2. Prediction of the concentration of residual chlorine over space and time.
3. Calibration and validation of the hydraulic model using time-patterns.
4. Determination of the sensitivity of the residual chlorine model.

Main Issues/Problems of the Study

- 100 DMAs to improve the water supply network of Dhaka City.
- There is a protocol for chlorination at the pump stations of PTWs.
- Monitoring of residual chlorine, found absent in most DMAs.
- Chlorine is administered rather arbitrarily and its effectiveness in the water distribution system remains largely unknown.
- The concentration of residual chlorine within a water distribution network vary in accordance with the variation both for location and time.

Methodology or Approach used for the Study

- Selection of an existing water supply DMA
- Measurement of initial concentrations of residual chlorine (RC) in the DMA.
- Prediction of concentration of RC over the space and time.
- Application of EPANET 2.0 version software as a predictive tool.
- Collection of existing water distribution network, it's time pattern and other hydraulic data.
- Determination of the bulk decay rate constant (Kb) from BUET.
- Determination of wall decay rate constant (Kw) through calibration and validation of residual chlorine model (RCM) and field observation data.

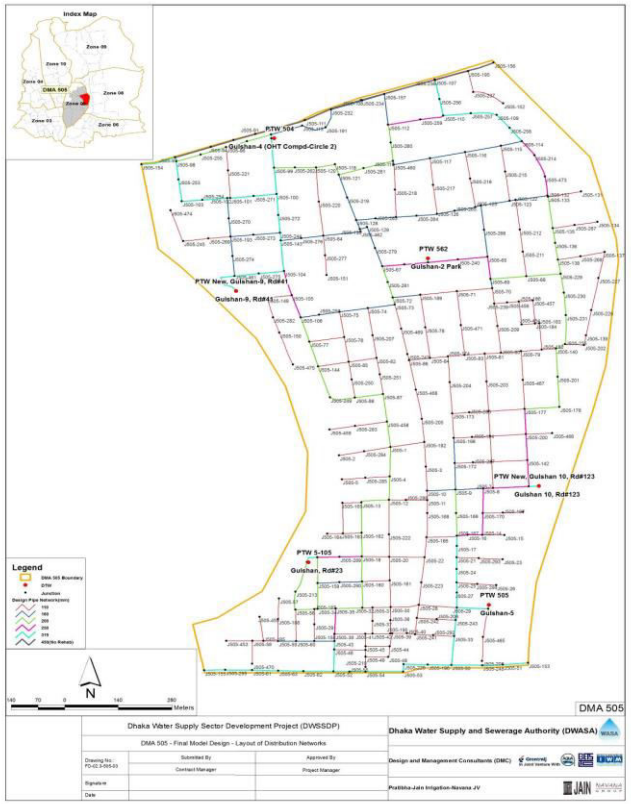

Figure 1: Layout of the existing water distribution network with 6 PTWs in DMA 505

Results and Conclusion Derived from the Study

- The average value of K_b found **- 0.2975h-1**.
- The value of ***Kw*** achieved as **- 0.0065 fts-1**

Table 1: Predicted and observed time series value of residual chlorine for node INP1/J505-172.

Time of residual chlorine prediction	Residual chlorine predicted for node INP1/J505-172 (in mg/l)				Residual chlorine observed for node INP1/J505-172 (in mg/l)
	When, k_b= -0.2975 h^{-1} and k_w= -0.65 ft/s	When, k_b= -0.2975 h^{-1} and k_w= -0.065 ft/s	When, k_b= -0.2975 h^{-1} and k_w= -0.0065 ft/s	When, k_b= -0.2975 h^{-1} and k_w= - 0.00065 ft/s	
2.00 Hrs	0.23	0.28	0.30	0.30	0.30
8.00 Hrs	0.23	0.28	0.29	0.29	0.29
14.00 Hrs	0.25	0.30	0.31	0.31	0.31
20.00 Hrs	0.25	0.30	0.31	0.31	0.31
26.00 Hrs	0.27	0.33	0.35	0.35	0.34
32.00 Hrs	0.23	0.28	0.29	0.29	0.30
38.00 Hrs	0.25	0.30	0.31	0.31	0.31
44.00 Hrs	0.25	0.30	0.31	0.31	0.30

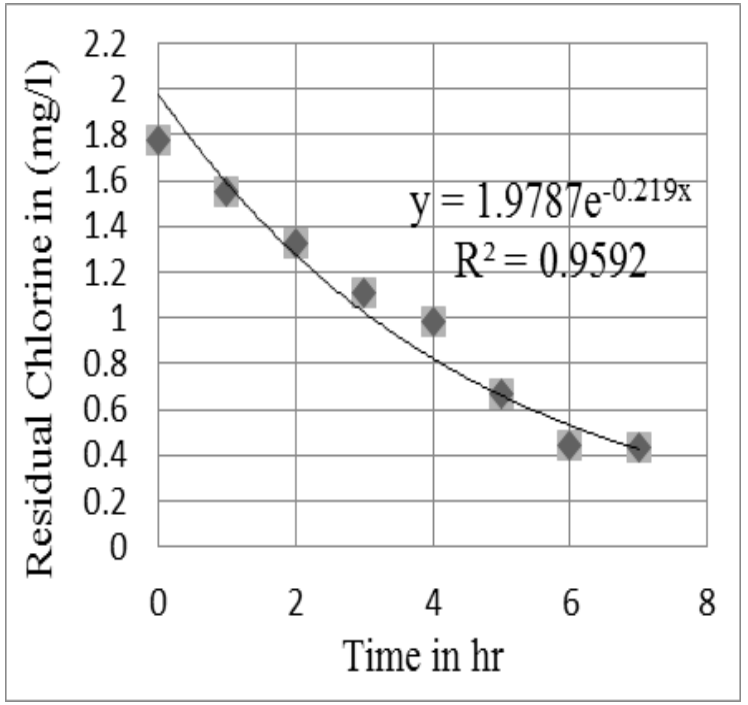

Figure 2: Chlorine decay at bulk fluid and respective first order adjustment of raw water sample of PTW 505 Gulshan-6 of DMA 505

Results and Conclusion Derived from the Study contd.

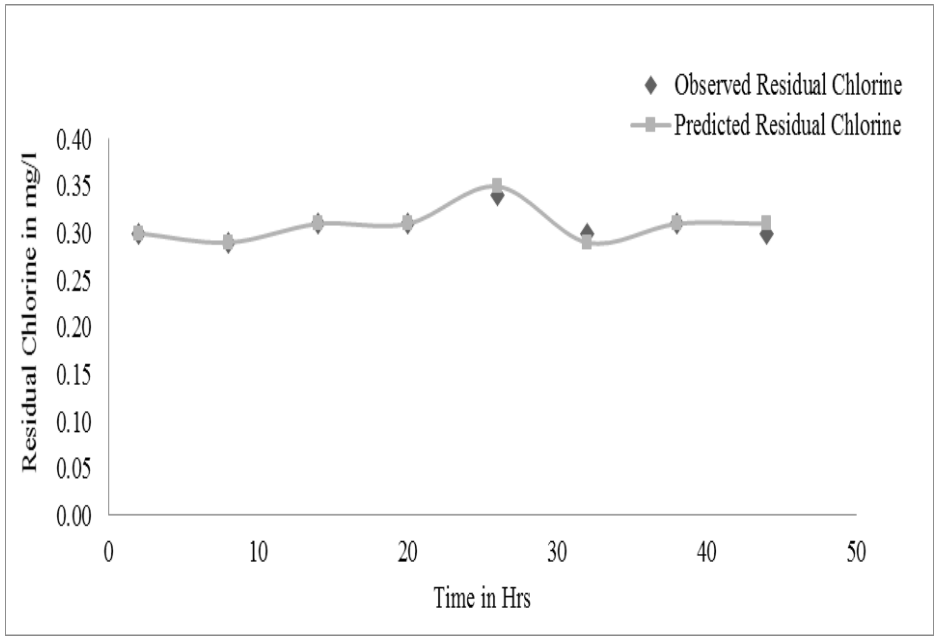

Figure 3: Time series of observed residual chlorine and predicted residual chlorine for intermediate point INP1/J505-172 for the value of kw = -0.0065 ft/s and kb = -0.2975 h-1

Table 2: Predicted and observed time series value of residual chlorine for node INP2/J505-198.

Time of residual chlorine prediction	Residual chlorine predicted for node INP2/J505-198 (in mg/l)				Residual chlorine observed for node INP2/J505-198 (in mg/l)
	When, k_b= -0.2975 h^{-1} and k_w= -0.65 ft/s	When, k_b= -0.2975 h^{-1} and k_w= - 0.065 ft/s	When, k_b= -0.2975 h^{-1} and k_w= - 0.0065 ft/s	When, k_b= -0.2975 h^{-1} and k_w= - 0.00065 ft/s	
2.00 Hrs	0.22	0.28	0.30	0.30	0.29
8.00 Hrs	0.19	0.25	0.26	0.26	0.27
14.00 Hrs	0.23	0.29	0.31	0.31	0.30
20.00 Hrs	0.23	0.29	0.31	0.31	0.31
26.00 Hrs	0.24	0.32	0.34	0.34	0.35
32.00 Hrs	0.19	0.25	0.26	0.26	0.27
38.00 Hrs	0.23	0.29	0.31	0.31	0.30
44.00 Hrs	0.23	0.29	0.31	0.31	0.31

Results and Conclusion Derived from the Study contd.

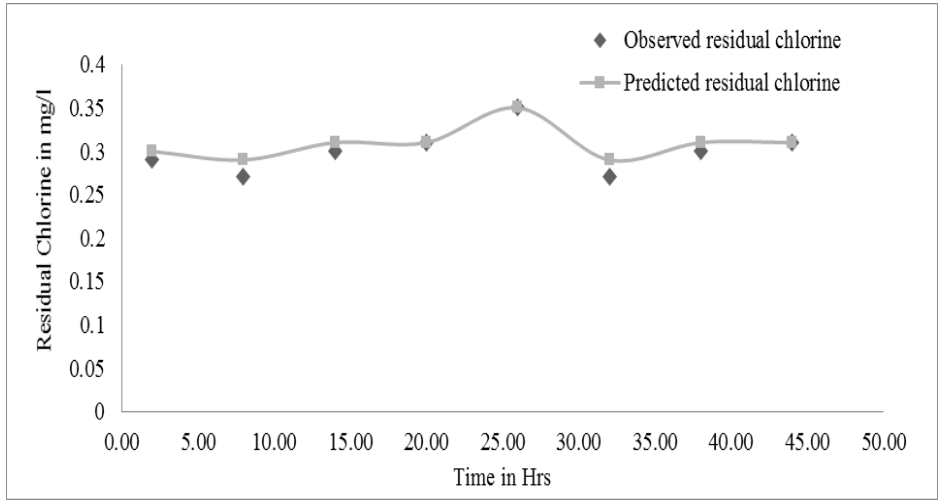

Figure 4: Time series of observed residual chlorine and predicted residual chlorine for intermediate point INP2/J505-198 for the value of kw = -0.0065 ft/s and kb = -0.2975 h-1.

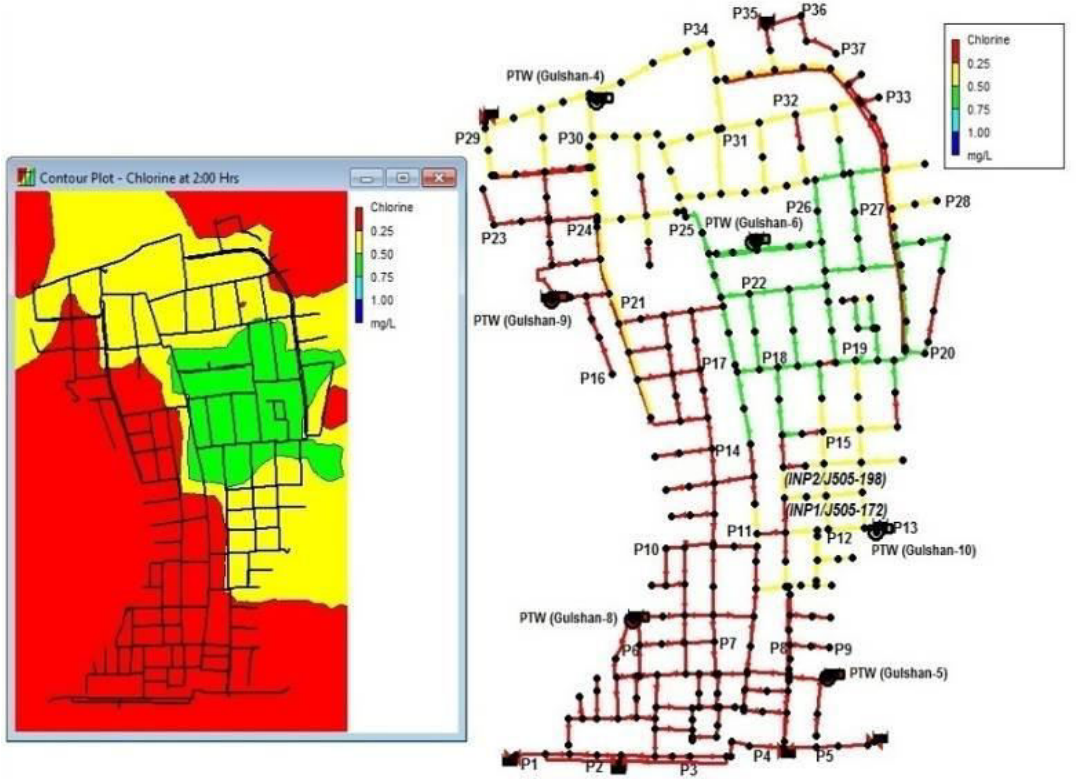

Figure 5: Contour map of residual chlorine model when, k_b = -0.2975 h^{-1} and k_w = - 0.0065 ft/s at 2.00 Hrs.

Results and Conclusion Derived from the Study contd.

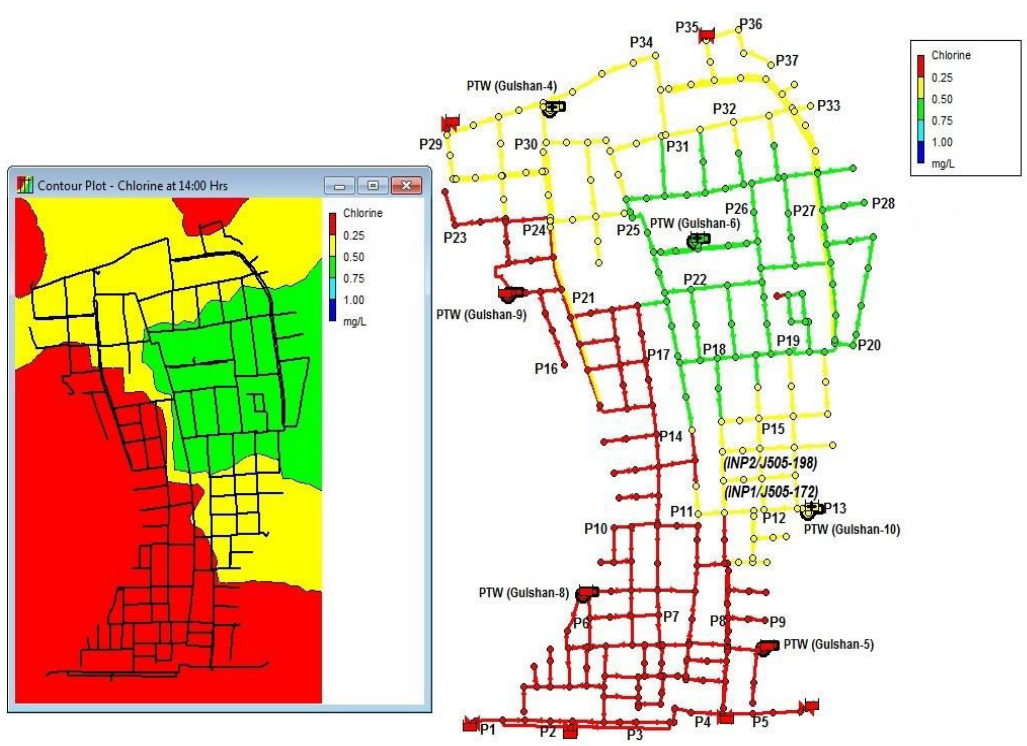

Figure 6: Contour plot of baseline residual chlorine scenario at 14:00 Hrs.

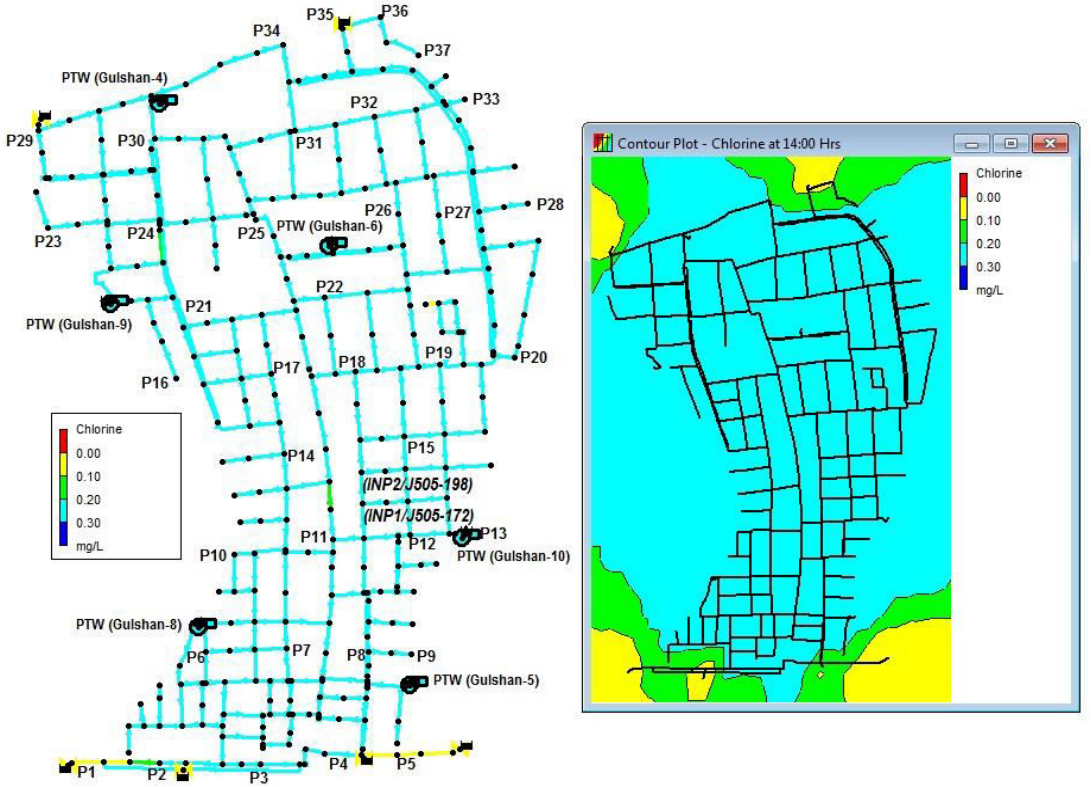

Figure 7: Contour plot of 5th residual chlorine improvement scenario at 14:00 Hrs.

Main Findings of the Study

The main findings of the present study are the following:

1. Significantly higher value of $\boldsymbol{k_b}$ in the PTWs and moderately high temperature over the DMA.
2. The value of k_w was nearly same to the $\boldsymbol{k_w}$ values in literature.
3. More than 50% pipes were found with zero residual chlorine at baseline condition.
4. In the baseline condition, only chlorine two injection points were available.
5. Insufficient coverage of residual chlorine in DMA.
6. Observed and predicted values found close to each other.
7. Simulation of different chlorine injection strategies was made to ensure the full chlorine coverage of the DMA.
8. 100% chlorine coverage could not be obtained over 24 hours.

Reference

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Thank You All