Assessment of drinking water quality in water distribution system at new and old residential area at Kangar, Perlis

S N A Mohd Sabri¹, W A A Wan Ahmad¹, A N Kamarudzaman¹ and M F Ab Jalil²

¹Water Research Group, School of Environmental Engineering, Universiti Malaysia Perlis (UniMAP), Kompleks Pusat Pengajian Jejawi 3, 02600 Arau, Perlis, Malaysia
²Perlis State Department of Environment, 2nd Floor, KWSP Building, Jalan Bukit Lagi, 01000 Kangar, Perlis, Malaysia

E-mail: ainnihla@unimap.edu.my

Abstract. Clean and safe drinking water is fundamental for human. Contaminated water can cause a vector of disease transmission and human health problem unless it is safe to drink. Although, a lot of technology developed to enhance the protected consuming water quality, water distribution system can adversely have an effect on the drinking water quality before it supplied to consumers. The aim of this study is to assess the physical and chemical parameters of drinking water quality in water distribution system at the old and new residential area in Kangar, Perlis. The water samples from tap water of old and new residential areas were collected and analysed for physical parameters (turbidity and colour) and chemical parameters (pH, free chlorine and ammoniacal nitrogen). From the findings, all the parameters tested complied to the limits set in the guidelines of the World Health Organization (WHO) and National Water Quality Standards of Malaysia.

1. Introduction

Water is important for all living being. People are consuming ample of water in daily lives for drinking, cooking, cleaning and other activities. However, human health can be affected if consuming contaminated water [1]. Usually, water will undergo several treatment process such as physical, chemical and biological process which helps to remove contaminants in the water and safe for drinking. Safe drinking water is one of the essential necessities for ethic health, development and well-being [2]. Safe drinking water means that water is free from pathogens, no toxic chemical, clear, tasteless and colourless [3]. Although a lot of technology developed to enhance the protected consuming water quality, water distribution system can adversely have an effect on the drinking water quality before it supplies to consumers. Water quality deteriorates as it travels through a drinking water distribution system. Parameters and reactions that are considered of interest include disinfectant residual and disinfectant by-product formation, nitrification, bacterial regrowth, corrosion, sedimentation, temperature, and taste and odour [4]. Even though water treatment plants have been improving in facilities to get better quality of drinking water, however, contaminated of water quality always occur in pipe distribution cause of different material pipeline, cross-connected pipeline, water backflow and low pipe pressure [5].

In the water distribution system, an old pipeline might have a sign of corrosion and impurities that will lead to the poor quality of water distribution. According to Ainswaorth and Water [6],
maintaining and operate of distribution pipeline system might be difficult as water distribution infrastructure usually complex and buried underground. Moreover, there is no person that will monitor the quality of drinking water at residential house regularly. The monitoring of the water quality only conducted at water treatment plant. Pipeline maintenance will only being conducted when there is a problem such as leakage.

Therefore, this research was conducted to monitor the drinking water quality for old and new residential areas, to do a comparison for both areas and also to investigate whether the distribution system was capable of maintaining good water quality from water treatment plant until the end-user.

2. Materials and Methods

2.1. Study area and sampling points
The water samples were taken at several residential areas around Kangar, Perlis for both, old residential area and new developed residential house. Taman Kemajuan, Taman Bukit Kaya and Taman Seri Manis have been selected as old residential houses, whereas, Taman Utama, Taman Indah Bintong and Taman Syed Alwi have been selected for new residential areas. In each residential area, three houses were chosen as sampling location to collect water samples from their tap water. For each house, two samples with approximately one litres were taken for lab testing. Figure 1 shows the location of water samples collected and type of material pipeline use at these distribution. The condition of new developed area must be at least 5 years operated and the old residential area must be more than 5 years operated or more. According to Syarikat Air Perlis Sdn. Bhd., majority of old residential area which had been distributed more than 20 years still using asbestos cement pipe, for instance, Taman Kemajuan and Taman Sri Manis while for the new residential area are using HDPE pipe.

![Figure 1. Location of water sample that been collected and type of pipe material use.](image)

2.2. Water Quality Analysis
The drinking water quality parameters were selected based on World Health Organization (WHO) and National Water Quality Standard for Malaysia. The physical parameters that have been analysed were turbidity and colour. While, for chemical parameters involved pH value, free chlorine and ammoniacal nitrogen. Table 1 shows the method used for water quality analysis.
Table 1. Methods for water quality analysis [7].

| Parameter               | Method                                      |
|-------------------------|---------------------------------------------|
| Turbidity               | 2130 B. Nephelometric method                |
| Colour                  | 8025: Platinum-Cobalt Standard Method       |
| pH                      | 4500-H* B. electrometric Method             |
| Free Chlorine           | Diethyl Phenylendiamine (DPD) Method        |
| Ammoniacal Nitrogen     | 8038: Nessler Method                        |

2.3. Data analysis

The data obtained from the laboratory were compared to the World Health Organization (WHO) and National Water Quality Standard of Malaysia as shown in Table 2.

Table 2. The guidelines of drinking water quality based on WHO standards and National Water Quality Standard of Malaysia.

| Parameter               | Unit | WHO Guidelines [8] | National Water Quality Standard of Malaysia for Drinking Water [9] |
|-------------------------|------|--------------------|---------------------------------------------------------------------|
| Turbidity               | NTU  | 5                  | 5                                                                    |
| Colour                  | TCU  | 15                 | 15                                                                  |
| pH                      |      | 6.5 - 8.5          | 6.5 - 9.0                                                           |
| Free Chlorine           | mg/L | 0.3 - 5.0          | 0.2 - 5.0                                                           |
| Ammoniacal Nitrogen     | mg/L | 1.5                | 1.5                                                                 |

3. Results and Discussion

3.1. Turbidity

Figure 2 shows turbidity values of tap water for new and old residential areas in Kangar, Perlis. All the turbidity values measured in the household tap water samples were less than 2 NTU. The turbidity measured at Taman Kemajuan, Taman Bukit Kaya, Taman Sri Manis, Taman Syed Alwi, Taman Bintong Aman and Taman Utama were 1.75 NTU, 1.83 NTU, 1.54 NTU, 1 NTU, 1.33 NTU and 2.09 NTU, respectively. The average for turbidity value for new and old residential area is 1.59 NTU. The value is safe for drinking and below the recommended value by World Health Organization and National Water Quality of Malaysia which is less than 5 NTU for safe drinking water. The highest value of turbidity is at Taman Utama with 2.09 NTU and the lowest value of turbidity is at Taman Syed Alwi with 1 NTU. The highest value could be due to availability of decay products and particles derived from the material used in pipes of the water supply distribution system [10]. However, according to Health Canada [11], water sources with turbidity more than 1 NTU can distribute quantities of sediment in water distribution system and resulting in material corrosion within the internal surface of distribution system and degradation of drinking water quality. In addition, Mekonnen [12] claimed that safe drinking water using chlorine as disinfectants should be less than 1 NTU.
Figure 2. Turbidity values for tap water in residential areas at Kangar, Perlis.

3.2. Colour

Figure 3 shows the results of colour for tap water in new and old residential areas at Kangar, Perlis. The colour measured at Taman Kemajuan, Taman Bukit Kaya, Taman Sri Manis, Taman Syed Alwi, Taman Bintong Aman and Taman Utama are 7.3 TCU, 11.3 TCU, 12 TCU, 7.5 TCU, 11 TCU, 14.6 TCU, respectively. All the value for colour at the selected area in Kangar, Perlis complied to the limits set by WHO and NQWS guideline which is less than 15 TCU. The highest value of colour is at Taman Utama with the value 14.6 TCU at new residential area, followed by Taman Sri Manis and Taman Bukit Kaya at old residential area with value 12 TCU and 11.3 TCU, respectively. Water samples from these residential areas were yellowish compared to other sample in different area. Brown, red, orange or yellow water is usually caused by the release of corrosion product from iron pipe, which lead to formation of ferric particles and causes red or yellow colour in tap water [13]. Furthermore, the high value of colour at Taman Utama was due to the maintenance work is being carried out in that area. The maintenance of water distribution pipe may affect the water flow in distribution system, plus affect the colour of water.

Figure 3. Colour of tap water in residential areas at Kangar, Perlis.
3.3. pH

Figure 4 shows the pH values for tap water sample at old and new residential area. The pH values measured at Taman Kemajuan, Taman Bukit Kaya, Taman Sri Manis, Taman Syed Alwi, Taman Bintong Aman and Taman Utama are 6.4, 6.5, 7.3, 6.6, 7.4 and 7.4. Generally, the pH values of tap water in these areas were acceptable as they fell within the recommended standards of pH 6.5 to 8.5 for drinking water based on WHO guidelines, while 6.5 to 9.0 for NWQS guidelines. Based on Figure 4, it can be seen that the water in old residential areas are more acidic compared to new residential areas. New residential areas are more to alkali because mostly the value of pH at new residential area are above 7. However, the lower the pH, the higher the potential level of corrosion in water supply pipelines [14]. The acidic water can degrade or corrode the internal metal surfaces in the distribution pipelines. If the tap water is above pH 6, then corrosion of lead and cadmium is insignificant [15]. In this study, the pH values of tap water in Taman Indah and Taman Sri Manis, Taman Bintong Aman and Taman Utama were above 7. The corrosion may not be significant, but the disinfection would be less effective at pH higher than 7. While the pH value at Taman Kemajuan, Taman Bukit Kaya and Taman Syed Alwi, the pH level is lower than 7. It is possible that the corrosion of old pipeline may be occurring in the distribution pipes.

![Figure 4. pH value of tap water in residential areas at Kangar, Perlis.](image)

3.4. Free chlorine

Chlorine is widely used in Malaysia to disinfect drinking water. However, it is important to control the concentration of free chlorine in the water, as any free chlorine will affects the taste and odour of water. Even though the guideline of WHO and NWQS is 0.2 - 5.0 mg/L, concentration of chlorine above 2 mg/L may give rise to complaints from consumer as it affect the test and odour for drinking water. This because chlorine is usually present in disinfected drinking water at concentration of 0.2 to 1.0 mg/L. As shown in the Figure 5, the residual free chlorine in sample water of these selected areas varies 0.58 mg/L to 1.29 mg/L with an average of 0.94 mg/L. The free chlorine measured at Taman Kemajuan, Taman Bukit Kaya, Taman Sri Manis, Taman Syed Alwi, Taman Bintong Aman and Taman Utama are 1 mg/L, 0.88 mg/L, 1.29 mg/L,0.06 mg/L, 1.2 mg/L and 0.58 mg/L, respectively. This was considered as adequate to ensure the protection against any microbial contamination in the water supply system. A low level of residual chlorine generally shows the effectiveness of chlorine as a disinfectant in sample water. However, if the level is too high then there might be complaints from the residences regarding taste and odour problems.

From the Figure 5, it shown that the value of free chlorine value for Taman Sri Manis and Taman Bintong Aman is quiet high compared than other residents area which are 1.29 mg/L and 1.2 mg/L.
The value are support with, during collected of water sample at that area, we receive complains from consumer state that the tap water have brackish taste and have chlorine odour. However the lowest value for free chlorine at residential in Kangar, Perlis is Taman Utama with 0.58 mg/L. The chlorine degradation might be attributed to biofilm, pipeline material or hydraulics condition [5]. Other than that, Mekonen [12] also stated that long distance between water treatment and household residential area can increasing water time flow in distribution system and deplete the free chlorine before it reaches the household taps. Generally, free chlorine in the tap water in these old and new residential area in Kangar, Perlis with range value 0.58 mg/L to 1.29 mg/L was acceptable as they fell within the recommended value of WHO and NWQS which are 0.3 to 5.0 mg/L and 0.2 to 5.0 mg/L, respectively for safe drinking water.

![Figure 5. Free chlorine value of tap water for residential areas in Kangar, Perlis.](image)

3.5. Ammoniacal Nitrogen

Ammonia is a colourless, pungent gaseous compound of hydrogen and nitrogen that is highly soluble in water. Ammoniacal nitrogen may be present in drinking water as a result of disinfection with chloramines. Figure 6 shows ammoniacal nitrogen concentration in tap water was varied from 0.01 to 0.05 mg/L. The ammoniacal nitrogen concentration measured at Taman Kemajuan, Taman Bukit Kaya, Taman Sri Manis, Taman Syed Alwi, Taman Bintong Aman and Taman Utama are 0.03 mg/L, 0.02 mg/L, 0.02 mg/L, 0.05 mg/L, 0.01 mg/L and 0.02 mg/L, respectively. The ammoniacal nitrogen results for old and new residential areas in Kangar, Perlis with average 0.03 mg/L were within the recommended value that stated by WHO and NWQS guideline which is below 1.5 mg/L for drinking water.
4. Conclusion
Overall, from the analysis of the water samples collected from the new and old residential areas in Kangar, Perlis, the water quality in distribution pipes were considered safe for drinking purpose. All the parameters have complied with the guidelines of the World Health Organization (WHO) and National Water Quality Standards of Malaysia. In this study, the corrosion might be occurred in the pipeline at the old residential area that using Asbestos Cement (AC) pipe in the distribution system pipeline since the pH values were lower.

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