Bangladesh J. Bot. **49**(1): 191-196, 2020 (March) **- Short communication**

AN INVESTIGATION OF TAP WATER QUALITY IN KUANTAN, PAHANG, MALAYSIA

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Keywords: Tap water quality, Fungi, Heavy metal

Abstract

Assessment of the quality of tap water at Kuantan area of Pahang, Malaysia was investigated. The parameters analyzed were total coliform, *Escherichia coli*, pH, total hardness, sulfate, and selected heavy metal based on drinking water quality standard Malaysia and WHO. The results showed that the fungi in the tap water in Kuantan area in different concentrations were *Asperqillus* sp., *Rhodotorula mucilaqinosa, Penicillium citrinum, Cladosporium cladosporioides, Cerrena* sp., *Aspergillus aculeatus, A. flavus, Cryptococcus* sp., *Cladosporium perangustum, Purpureocillium lilacinum* and *Candida catenulata.* The residual free chlorine varied from 0.05 to 1.97 mg/l.

The availability of safe water supplies is an essential need for all living things, including humans (Chouhan *et al.* 2015). The quality of water supplied through pipe not always safe for human consumption (Mirzabeygi *et al.* 2016). Drinking water should not contain unwanted organic and inorganic contaminants and pathogenic organisms (Ernest *et al.* 2017). Microbial communities present in drinking water has changed due to the improper distribution system (Ling *et al.* 2018). Most studies and international standards have not addressed the presence of fungi within the water distribution network, which negatively affects the quality of drinking water. Possible reasons may be the lack of knowledge of the fungal load in water, divergent cultivation methods and consequently the low number of reports indicating fungal presence in tap water and the occurrence of diseases in humans (Kauffmann *et al.* 2016).

Many water resources, including surface and ground water that contribute to the industrial and economic development in Malaysia (Salah *et al.* 2018), are treated using a conventional method (Ong 2001). Several studies have shown that the condition of tap water supplied to residences with an unpleasant taste and an unacceptable appearance in certain districts in Pahang state, that might be due to the taste of chlorinated tap water (Azlan *et al.* 2012). In the present study, the quality of the tap water in East Coast State of Peninsular, Malaysia has evaluated.

The fieldwork comprises testing of tap water samples in selected areas in the Kuantan city with different distribution distances from the water treatment plant. Thirty water samples were collected from public buildings and private residences at the study area. The study area is located at latitude 3°49′N and longitude 103°20′E.

The water samples were collected from the tap in different range distances (0 to 30 km), which receive direct water supply from Semambu Water Treatment Plant, Kuantan. All the samples were analyzed within 4 hrs after sampling at the Environmental Laboratory, Faculty of Engineering Technology, University Malaysia, Pahang, Malaysia. Before taking the samples, the tap was wiped to remove any dirt by a clean cloth. Then the tap was turned on at maximum flow for three min. The sampling bottle was rinsed three times with the tap water before collection. The samples from tap water were collected in a 1.5 litre polyethylene plastic bottle.

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The samples were analyzed according to standard methods of the American Public Health Association (APHA 1992). Physicochemical and biological parameters of the collected water samples were measured. Total 11 parameters studied from the water samples consisting of three physical, five chemicals and three biological. Water temperature was measured by thermometer and counted at °C; while the turbidity, color, pH, total hardness ($CaCo_3$), sulfate (SO_4), chloride (Cl_2) and heavy metal contents were measured by APHA. The total coliform and *E. coli* count was done by Colilert method and fungal count was done by CFU.

The temperature of the water samples was almost equal at the different points along the study site and it was 25 - 26^{o}C. High temperature enhances the microbial growth and increases the odor, taste, color, and corrosion of the sample water (WHO 2017).

The color of the water is often caused by the presence of organic matter or iron in the water. The color of tap water in Kuantan ranged from 0 - 49 TCU with an average of 10.3 (Table 1). Levels above 15 TCU are visible for humans and it is recommended by the Malaysia food Act 1983 and WHO 2017.

Table 1. Range of values of the parameters studied with number of samples in brackets.

Parameters	Range of values of the parameter studied with number of samples in brackets			
Color (CU)	0 - 2 (7)	3 - 8 (11)	9 - 18 (7)	Above 18 (5)
Turbidity (NTU)	0 - 2 (24)	3 - 8 (2)	9 - 18 (3)	Above 18 (1)
pH	5.3 - 6.5 (6)	6.6 - 7.5 (15)	7.6 - 8.7 (8)	Above 8.8 (1)
Free chlorine (Cl_2)	0-05 - 1.0 (18)	1.1 - 1.5 (7)	1.6 - 1.9 (5)	Above 2 (0)
CFU	0 - 25 (1)	26 - 50 (4)	51 - 100 (23)	Above 100 (2)

The measure of turbidity is an expression of the absorption and scattering of light through the water samples. The presence of particles in water such as clay, organic and inorganic matter, plankton, and silt increases the turbidity. The turbidity of water sample ranged from 0 - 46 NTU with an average of 3.8 (Table 1). The turbidity of tap water, in general, was an acceptable level, except 6 water samples that did not comply with the recommended value below 4 NTU for safe drinking water (WHO 2017). The pH of tap water ranged from 5.3 - 8.9 (Table 1). The pH of water samples was an acceptable level, except for 5 samples was < 6.5 and one sample was >8.5 in the Kuantan area. Drinking water with pH 6.5 - 8.5 is generally considered as satisfactory level as per standards of Malaysia food Act (WHO 2017).

Hardness is a measure of the content of calcium and magnesium in water. Public acceptability of the degree of total hardness of water may vary considerably from one country to country. The taste threshold for the calcium ion is in the range of 100 - 300 mg/l, according to the anion present in water and the taste threshold for magnesium anions is probably less sensitive than calcium anions (WHO 2017). The total hardness of tap water ranged from 5 - 36 mg/l with an average of 14.63 mg/l. The total hardness of tap water, in general, was an acceptable value according to drinking water quality standards.

The presence of sulfate in drinking water can cause noticeable taste, and very high levels might cause a laxative effect in unaccustomed consumers. The maximum acceptable value of the sulfate in drinking water is 250 mg/l according to the Malaysia food Act (WHO 2017). The concentration of sulfate in the tap water of the selected areas ranged from < 5 - 9 mg/l. The consumer complaint from the tap water taste when the chlorine concentration is >5 mg/l. According to WHO (2017) allowable of free chlorine concentrations residual in drinking water is 0.3 - 5 mg/l. The residual free chlorine in the tap water of these selected areas varied from 0.05 - 1.97 mg/l (Table 1). The heavy metal was highlighted in this study including zinc, cadmium, chromium, iron, copper, lead, manganese, magnesium, nickel, silver, aluminum, boron, sodium and barium. All heavy metals were measured and found to be in acceptable value according to the standards of the Malaysia food Act 1983 (WHO 2017).

If total coliform and *E. coli* are detected in water, it is an indicator that the water is contaminated by fecal or other contaminants meaning that the water is a direct health risk. The limits of the total coliform and *E. coli* in drinking water to be suitable must have a limit for <1 number of bacteria per 100 ml (WHO 2017). The results showed that the range of the total coliform and *E. coli* in the tap water was equal <1 in each sample in the Kuantan area.

Fungi growing in biofilms inside the pipelines and in tap water affect the taste and odor (WHO 2017, Kadaifciler and Demirel 2018). In the last 30 years, the presence of a high variety of fungi was reported from European water, including surface, ground and tap water intended for human consumption (Sonigo *et al*. 2011). The results showed that there were fungi in the tap water in the Kuantan area in different concentration based on the distance between the water treatment plant and the samples collection (Table 1).

All 30 water samples were analyzed for the presence of selected cultivable fungi, and one species of bacterium *Cronobacter sakazakii* was present in 50% of the water samples. One hundred per cent of tap water samples were positive for at least one or two fungal species. Across all the sampling carried out in the present study, a total of 2104 colonies were isolated from water samples and cultivated for identification. In addition, the fungal species and bacteria isolated from the tap water in the Kuantan area are presented in Table 2. *Aspergillus* sp. and *Rhodotorula mucilaginosa* were widespread in the water samples about 73, 63%, respectively in Kuantan area. *Penicillium citrinum* was 46%, while *Cladosporium cladosporioides*, *Cerrena* sp., *Aspergillus aculeatus*, *A. flavus*, *Cryptococcus* sp. were 40, 33, 30, 13 and 10%, respectively and *Cladosporium perangustum*, *Purpureocillium lilacinum,* and *Candida catenulata* were about 3% in the study.

High quality drinking water from treatment plants is exposed to pollution and significant deterioration through the drinking water distribution system (DWDS) which is before access to taps of users (Fish *et al.* 2017). Many reactions, chemicals, and biological agents may enter the pipeline from several sources as well as interactions with pipe walls, which create a major problem leading to outbreaks of diverse diseases and poor water quality (Miller *et al.* 2017). The distribution network must be planned to avoid zones of water stagnation or high-water residence times in pipes and sediment accumulation (Simões and Simões 2013). The factors have highlighted control of the growth and increase the number of microbes present in the system of a drinking water distribution network.

Water disinfection is a process used to kill or irreversibly inactivate microorganisms that have passed through the treatment processes and to ensure microbiologically safe water through the DWDS. However, this must be done carefully; high chlorine concentrations can cause organoleptic problems, an increase in the production of carcinogenic DBPs, namely trihalomethanes and haloacetic acids, which are harmful to human health (Bhomick 2017).

Table 2. Fungal species and bacteria isolated from the tap water of Kuantan area.

No. of samples	*Aspergillus* sp.	*Penicillium citrinum*	*Cladosporium cladosporioides*	*Rhodotorula mucilaginosa*	*Crypto-coccus* sp.	*Cladosporium perangustum*	*Cerrena* sp.	*Candida catenu-lata*	*Aspergillus aculeatus*	*Aspergillus flavus*	*Purpureo-cillium lilacinum*	*Cronobacter sakazakii*
1	+	–	+	–	–	–	–	–	+	–	–	–
2	–	+	–	+	–	–	+	–	–	+	–	+
3	+	–	+	–	–	–	–	–	–	+	–	–
4	+	–	+	+	–	–	–	–	–	–	–	–
5	+	+	+	+	–	–	–	–	–	–	–	–
6	–	+	–	+	–	–	–	+	+	–	–	–
7	+	–	–	+	–	–	–	–	+	–	–	–
8	+	+	–	–	+	–	–	–	–	–	–	–
9	+	–	+	+	–	–	–	–	–	–	–	+
10	+	+	–	+	–	–	–	–	+	–	–	+
11	+	+	–	+	–	–	–	–	–	–	–	+
12	+	+	–	+	–	–	–	–	–	–	–	+
13	+	–	–	–	–	–	+	–	+	–	+	–
14	–	+	–	+	–	–	–	–	+	–	–	+
15	–	–	–	+	–	–	–	–	–	–	–	+
16	+	–	+	–	–	–	+	–	–	–	–	+
17	+	+	+	+	–	–	–	–	–	–	–	–
18	–	+	+	–	+	–	+	–	–	–	–	–
19	+	–	–	–	–	–	+	–	+	–	–	–
20	+	–	+	–	–	–	+	–	+	–	–	–
21	+	+	–	–	–	+	–	–	–	+	–	–
22	+	–	+	–	–	–	–	–	+	–	–	–
23	–	+	–	+	–	–	+	–	–	–	–	+
24	–	–	–	+	–	–	+	–	–	–	–	+
25	–	–	–	+	–	–	–	–	–	–	–	+
26	+	–	+	+	–	–	–	–	–	–	–	+
27	–	+	–	–	+	–	+	–	–	–	–	+
28	+	–	+	+	–	–	+	–	–	–	–	–
29	+	+	–	+	–	–	–	–	–	–	–	+
30	+	–	–	+	–	–	–	–	–	+	–	+

The service age of the pipes is an important factor that should be considered in the consumption of chlorine. This means that older pipes have more impact on the decay of chlorine concentration than new ones (Simões and Simões 2013).

Previously investigators have shown that the multiplication of microorganisms in biofilms along the distribution systems results in the deterioration of the bacteriological quality of drinking water, the development of odor or color as well as the acceleration of the phenomenon of corrosion within the pipework (Momba *et al.* 2000). Through this study a positive relationship observed in most samples and the distance between them and Semambu Water Treatment Plant, Kuantan were reported. On the other hand, the control of the growth of the pathogens inside the DWDS can be done by using the feasibility measures. Monitoring the disinfection concentration along with the distribution system to determine wherein the disinfection decay is the important viability measures (Liu *et al.* 2016). Water temperature affects the microbial growth rate, disinfection efficiency, pipe corrosion rates, and other phenomena associated with biofilm development, as well as the opportunity for microbes to enter the distribution system. Where nutrients are adequate, microbes generally grow more rapidly at warmer water temperatures than at colder temperatures (Rakić 2018). Thus, water temperatures between 25 and 26^{o}C, likely facilitate the growth of opportunistic pathogens in the DWDS as results shown in the study.

High-quality drinking water from treatment plants is exposed to pollution and significant deterioration through drinking water distribution system which is before access to faucets of users. This study has provided new data on the quality of drinking water in Kuantan region including pH determination, temperature, heavy metal, total hardness, turbidity, sulfate, color, chlorine, *Escherichia coli*, total coliform count, and fungal.

Acknowledgements

This study was supported by a scholarship under Libyan Ministry of Higher Education. Researchers are grateful to authorities of the University Malaysia Pahang and Faculty of Engineering Technology for their permission to use research facilities and supporting this research.

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(Manuscript received on 13 March, 2018; revised on 14 July, 2019)