

Short Communication

Indigenous drinking-water consumption pattern of residents in Kuching city: results of a pilot study

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ABSTRACT

Identifying the demographic factors that affect patterns is very important for determining drinking water sources within a community. Previous empirical studies mainly focussed on demographic factors affecting water demand in urban and semi-urban areas facing water shortage with little rainfall. However, studies on water consumption in tropical regions (average annual ~4,000 mm) is limited. This study aims to investigate relationships between drinking water patterns and demographic factors for Kuching community, Sarawak, Malaysia. Survey data were collected from 100 respondents using structured questionnaires through mail, drop-off and telephone surveys in March–December 2016. Results revealed that drinking water patterns are significantly correlated with source, income and education level. 46% of respondents preferred tap water as their drinking water source, followed by 31% for in-home water-treatment devices, 19% chose bottled water and only 4% still drink raw water. In terms of income and education level, 25% of respondents with diploma, degree and postgraduate academic qualifications, quantified as higher income group, installed in-home water-treatment devices. 21% of respondents with monthly income more than RM2500 also initiated installation of in-home water-treatment devices. In contrast, age, gender and religion were found to have little affect on drinking-water consumption patterns.

Key words | bottled water, demographic factors, drinking water consumption pattern, in-home water treatment device, raw water, tap water

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BACKGROUND

Water is vital for proper functioning of human-body mechanisms. Water is needed to regulate body temperature, helps in metabolism, transports nutrients and oxygen into cells, moisturizes air in the lungs, detoxifies, helps human organs to better absorb nutrients, and protects and moisturizes the joints. Hence, it is very important for a society to obtain clean and well-treated water, as untreated or contaminated water may cause epidemic gastrointestinal diseases (WHO 2004). The US Environmental Protection Agency (USEPA 1997) and Health & Welfare Canada (1981) state clearly that drinking-water consumption patterns are important for studying waterborne illness, waterborne

risk assessments and the formation of water quality guidelines.

In the past, data on water consumption patterns had been collected for descriptive purposes (Hossain *et al.* 2013; Singh & Turkiya 2013; Jain *et al.* 2014; Söderbergh *et al.* 2017) especially during the outbreak of epidemic gastrointestinal diseases (DeFelice *et al.* 2015; Bylund *et al.* 2017; Gleason & Fagliano 2017). However, data collected within this limited period are usually restricted to specific populations and it is less accurate. In recent years, water consumption patterns have been utilized as a basis for water-demand modelling (Avni *et al.* 2015). Artificial

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intelligence algorithms such as Kohonen Self-Organized Maps have also been applied to cluster water consumption patterns in the Greek islands (Laspidou *et al.* 2015).

While there is extensive literature on water consumption patterns for urban and semi-urban areas facing water shortage with little rainfall, there are few studies on water consumption in tropical regions. To date, no such study has been carried out for Kuching community, a tropical region with average annual rainfall of 4,000 mm, located in Sarawak State, Malaysia. Demographic factors such as age, gender, education level, jobs, income and living standards (Fan *et al.* 2013; Jain *et al.* 2014) affecting drinking-water consumption patterns for Kuching community remained unknown. Without this set of data, proper planning of water supply throughout the city cannot be achieved precisely. With the insight of the water consuming pattern, better water supply infrastructure can be planned for, so improving the life quality of Kuching community.

Therefore, a pilot study on drinking-water consumption pattern was carried out in Kuching city, between March and December 2016. Drinking-water consumption pattern is determined by analysing the harvested survey data. The objectives of this pilot study are to: estimate the daily water consumption for Kuching community; identify the drinking-water consumption pattern; and identify the demographic factors affecting the drinking-water consumption pattern in Kuching city.

Study area

Kuching is the capital and the most populous city in the state of Sarawak, Malaysia. The city is located at the southwest tip of Borneo island with latitude 1°32'41.1540" N and longitude 110°21'54.7884" E. Kuching city covers an area of 431 km² (166 mile²) with a population about 705,546 (Sarawak Population 2016). Average annual rainfall is 4,000 mm and Kuching is divided by the Sarawak River. The south comprises commercial and residential areas dominated by Chinese, while the north shore is predominantly Malay in character with old kampong houses lining the river. The southern part is under the jurisdiction of Kuching South City Council (MBKS) and the northern region is ruled by City Hall of Kuching North (DBKU) as presented in Figure 1(a).

Kuching prides itself on being one of the most multi-racial cities in Malaysia. The Chinese speak Hokkien, Hakka, Foochow, Cantonese, Teochew, Hainanese and Heng Hua. The Malays, who are Kuching's original inhabitants as well as migrants from neighbouring Indonesia, form only slightly less of the population than the Chinese. Ibans form about 5% of the population. There are also original Indian migrants who have lived in Kuching for many decades. The remainder are other indigenous races including Bidayus, Melanaus, Javanese and Orang Ulu settlers (Kuok *et al.* 2011).

Kuching enjoys sunshine throughout the year except for the monsoon season that runs through November to February. It is a peaceful place, hailstorms can occur sometimes, but strong winds, tremors and heavy thunderstorms are very unlikely.

Methodology

This research was conducted using a questionnaire approach to a random sample of residents in Kuching city between March and December 2016. Questionnaires were prepared in English, Chinese and Malay languages. Respondents could respond in the language that they are familiar with. Questionnaires were delivered to the respondents through mail and drop-off, and by telephone.

A total of 43 questions were prepared in the questionnaire. The questions related to demographic characteristics and socio-economic variables including income level, educational level, living area, source of drinking water, daily water consumption, preferred source of bottled water, preferred brand of bottled water, reason for selecting bottled water, source of raw water, treatment of raw water, preferred types and rating of in-home water-treatment device, monthly expenditure on drinking water, monthly drinking-water consumption and religion. Monthly water demand for each household can be estimated by converting monthly water bills into total amount of water used.

Approximate time for answering one questionnaire is about 15 minutes. Only one representative from each household is allowed to participate in the survey. Proxy respondents were adapted for individuals less than 12 years old. For respondents ranging from 12 to 18 years old, they responded at the discretion of their parent or

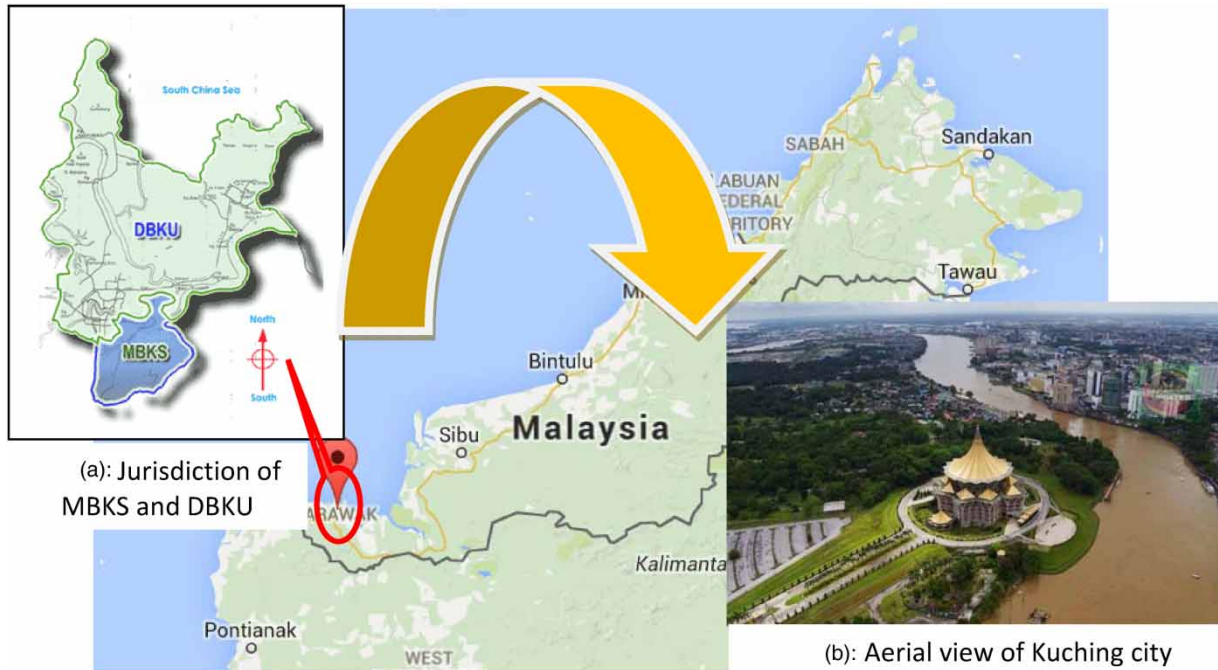


Figure 1 | Locality map of Kuching on Borneo Island.

guardian. Respondents were informed that the survey is voluntary and confidential.

Sample size for this survey was calculated based on Equation (1) (Creative Research System 2016). From Equation (1), a sample size of 96 was calculated and rounded up to 100.

$$\text{Sample size} = [Z^2 * (p) * (1 - p)] / c^2 \quad (1)$$

where $Z = Z$ value = 1.96 for confidence level of 95%, p = percentage picking a choice, which is taken as 50%, c = confidence interval of 10%, for confidence level of 95%.

The collected data were analysed using SPSS version 17.0 and Microsoft Excel. The analysed data will be presented in the form of frequency tables, pie and bar charts.

RESULTS AND DISCUSSION

Profile of respondents

The profile of the respondents and demographic characteristics are presented in Table 1. 57% of the respondents are

male and 43% are female. In terms of income, 14% of respondents have no income, mostly students, housewives and retired persons. In total, 15% of the respondents earning less than RM500 per month, whereas the percentage of respondents earning in the range of RM500–RM1500, RM1501–RM2500, RM2501–RM3500 and more than RM3500 per month are 16%, 18%, 15% and 22%, respectively. This reveals that most of the residents in Kuching are generally from medium to high range income groups.

For daily drinking-water consumption of the respondents, 14% of the respondents consume below 500 ml per day, 27% consume in the range 500–999 ml per day, 23% consume in the range of 1 litre to 1.9 litres per day, and 36% consume more than 2 litres per day. Collection data also revealed that 53% of the respondents staying in urban, 34% in suburban and the remaining 13% staying in rural areas. Kuching city had gone through drastic urbanization in the past few decades. Therefore, the percentage of respondents from the urban area is the highest and only a small percentage is from rural areas.

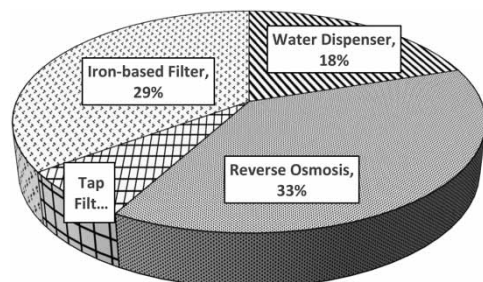
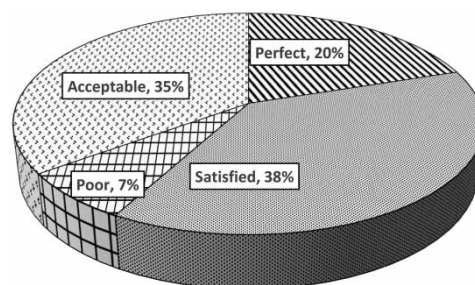
Survey results indicated that only 31% of the total respondents own an in-home water-treatment device. Out of the 31% of total respondents, 20% use a tap filter, 29%

Table 1 | Respondent profiles and demographic characteristics

| Profile | Number | Percentage (%) |
|--|--------|----------------|
| Gender | | |
| Male | 57 | 57 |
| Female | 43 | 43 |
| Monthly income (RM) | | |
| No income | 14 | 14 |
| <500 | 15 | 15 |
| 500–1,500 | 16 | 16 |
| 1,501–2,500 | 18 | 18 |
| 2,501–3,500 | 15 | 15 |
| >3,500 | 22 | 22 |
| Drinking-water consumption (ml per day) | | |
| <500 | 14 | 14 |
| 500–999 | 27 | 27 |
| 1,000–1,900 | 23 | 23 |
| >2,000 | 36 | 36 |
| Living area | | |
| Urban | 53 | 53 |
| Suburb | 34 | 34 |
| Rural | 13 | 13 |

use an ion-based filter, 33% use reverse osmosis, 18% own a water dispenser as presented in Figure 2. Collected data shows that the majority of the people use reverse osmosis or an ion-based filter due to the effectiveness and efficiency of water treatment processes, while fewer people use a tap filter or water dispenser.

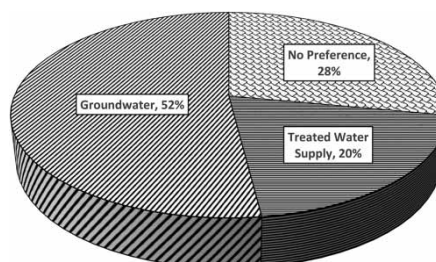
The survey also asked respondents to rate the satisfaction with their in-home water-treatment device. Figure 3 indicates that only 7% of the respondents gave a poor rating to their water-treatment device, most probably

**Figure 2** | Types of in-home water-treatment device.**Figure 3** | Satisfaction rating of the in-home water treatment device.

because of the usage of a less efficient and effective water-treatment device such as tap filter. Meanwhile, 35% rate their water-treatment device as fairly acceptable, 38% are satisfied with their water-treatment device and 20% proclaimed that their water-treatment device is functioning perfectly. Generally, most of the respondents are aware of the importance of using a water-treatment device for further treating the water supply before consumption.

The survey also found that 19% of the respondents in Kuching chose bottled water as their drinking water source. Two main water sources available for bottled water are treated water supply and groundwater. The survey results show that 52% of the total respondents prefer to consume groundwater source bottled water, while 20% prefer treated water supply bottled water. The remaining 28% do not have any preference as shown in Figure 4. Groundwater is generally preferred as it gets filtered naturally while percolating through sand and stones. Hence groundwater remains pure, clean, likely free from pathogenic bacteria, less risk of getting contaminated and can be used without further treatment.

The survey also further investigated selection criteria for bottled drinking water, including source, cost, brand and availability in the market. Figure 5 revealed that 37% of the

**Figure 4** | Preferred source of bottled water.

respondents would choose their bottled water according to the cost, 26% based on the water source, 11% would be more specific on the bottled water brands, and 5% according to its availability. The remaining 21% do not have any preference.

Demographic factors affecting the water consumption pattern

Drinking-water consumption pattern versus living area

Figure 6 presents the drinking water pattern versus living area for Kuching city. Survey results show that 20% of the respondents living in urban area use an in-home water-treatment device, 9% drink bottled water and 24% drink boiled water. In suburban areas, 10% of the respondents have an in-home water-treatment device, 8% drink bottled water and 16% drink tap water. Only 1% of respondents

have an in-home water-treatment device and 2% drink bottled water in rural areas. Most of the time, respondents in rural areas obtained their drinking water from tap or raw water.

Results revealed people living in urban areas have higher living standards, with better income to purchase an in-home water-treatment device. Water supply components such as water pipelines may deteriorate with age, water storage tanks for high rise buildings may not be well maintained. Therefore, the water supply needs further treatment to obtain better quality drinking water in urban areas.

The results also revealed that the bottled-water consumption rate is high in urban and suburban areas as bottled water is readily available. Most of the respondents prefer to consume boiled tap water, as a way to save costs. Tap water is also highly preferred as it is cheap and clean.

Drinking-water consumption pattern versus age group

Figure 7 illustrates the relationship of the drinking-water consumption pattern with different age categories. Results revealed that an in-home water-treatment device is popular and well accepted for age groups from 5 to 55 years old covering 29% of respondents, but less popular for elderly people (2% of respondents). It can be concluded that most of the respondents have high health awareness by further treating the water before consumption.

Meanwhile, it is observed that the percentage of bottled water consumption is popular for the age group

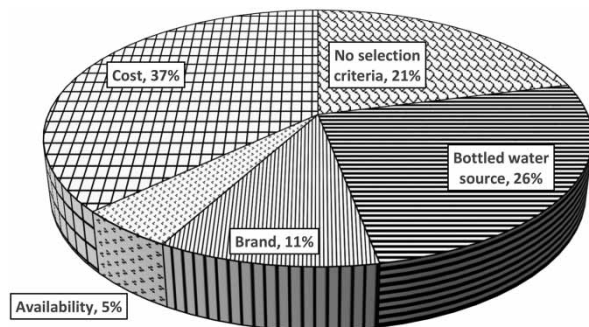


Figure 5 | Selection criteria for bottled water.

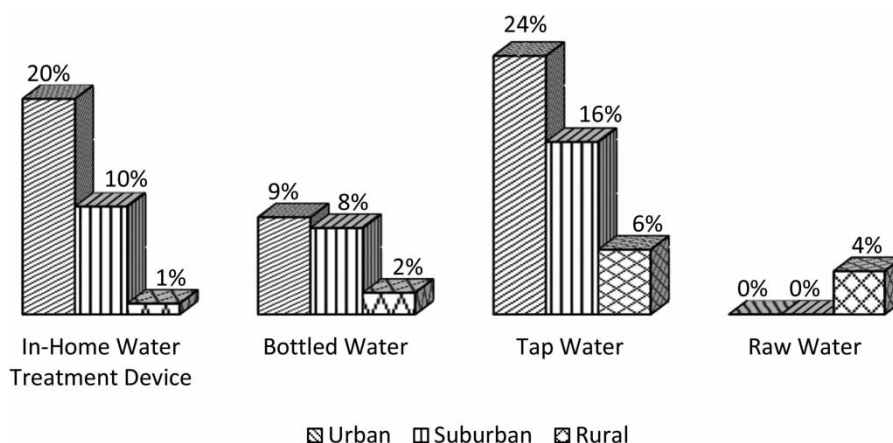


Figure 6 | Drinking water consumption pattern versus living area for Kuching city.

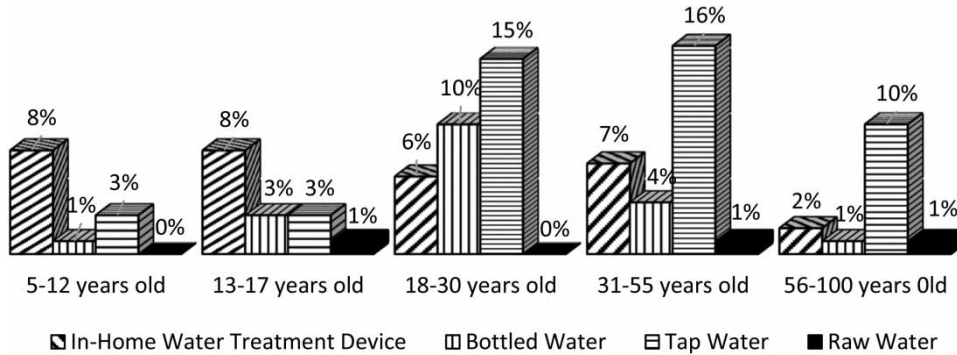


Figure 7 | Drinking water consumption pattern versus age group.

of 18–55 years old, where most are students or working adults with busy and hectic lives. This group of people may travel regularly and bottled water is the most convenient water source for them. Besides, 15% from group age 18–30, 16% from group age 31–55 and 10% from age category 56–100 years old boiled their drinking water source from tap water. Tap water is treated at a water treatment plant. Bacteria, virus and protozoa are killed through disinfection and boiling processes. Therefore, tap water remains as the most popular, cheap and safe drinking water source.

Drinking-water consumption pattern versus education level

Figure 8 presents the relationship of drinking-water consumption patterns and education levels. It can be seen that an in-home water-treatment device is well accepted by the respondents regardless of education level. This is proven by 10% from postgraduate respondents, 8% from degree level, 7% from diploma level, 4% from SPM level and 2%

from UPSR level use an in-home water-treatment device. Results also revealed that the percentage of respondents who consumed bottled water from postgraduate, degree, diploma, SPM and UPSR levels are 4%, 4%, 2%, 2% and 1%, respectively.

Tap water is the most popular drinking water source among the respondents regardless of education level. Results show that 8% of the respondents with postgraduate level, 8% with degree level, 11% with diploma level, 11% with SPM and 9% with UPSR qualifications used tap water as a drinking water source. Conversely, there are no respondents who consume raw water.

Drinking-water consumption pattern versus monthly income

Figure 9 illustrates the relationship between the drinking-consumption patterns and the income of the respondents. Results revealed that in-home water-treatment devices and bottled water remained popular for middle and high income groups as they are willing to spend more money to

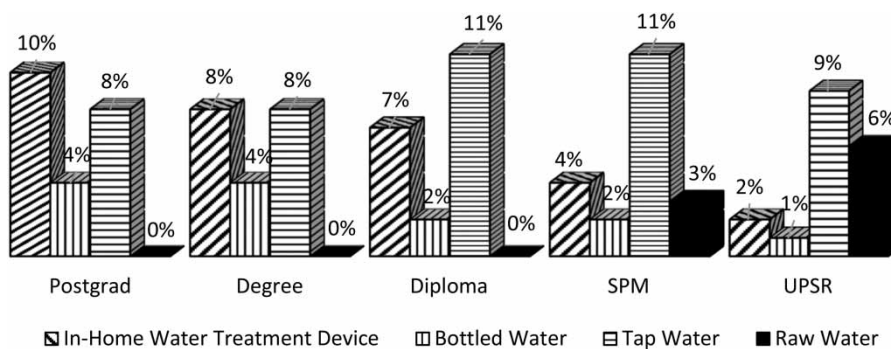


Figure 8 | Drinking water consumption pattern versus educational level.

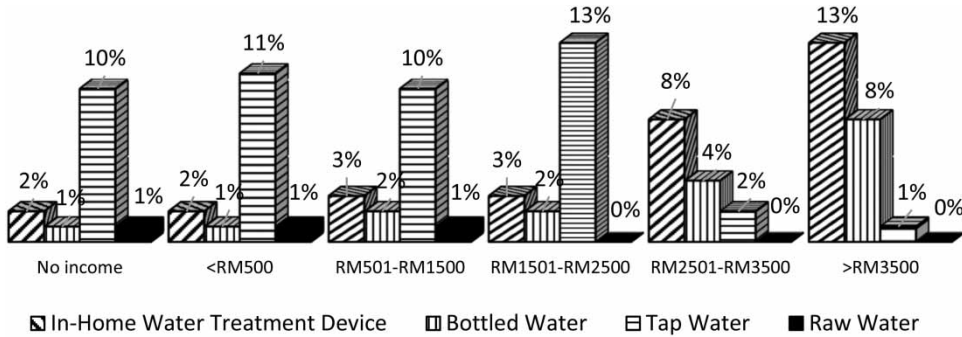


Figure 9 | Drinking water consumption patterns versus income of respondents.

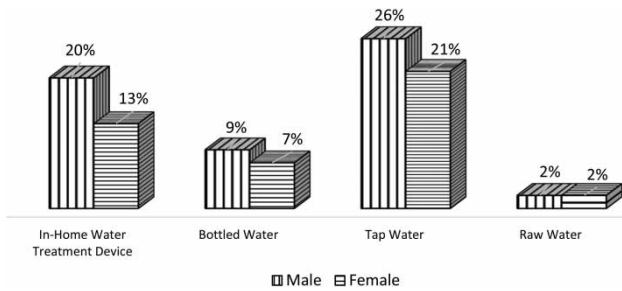


Figure 10 | Drinking water consumption pattern versus gender.

obtain a clean, healthy and reliable drinking water source. This reflects that income is the main factor affecting the choice of drinking water source. Meanwhile, tap water remains the most preferred drinking water source for lower and no income groups.

Drinking-water consumption pattern versus gender

Figure 10 illustrates the relationship between drinking-water consumption pattern and gender. Among the four drinking

water sources, both genders indicated that the most popular is tap water, followed by an in-home water-treatment device then bottled water. The least preferred drinking water source is raw water. This reveals that genders do not show any significant impact to the choices of drinking water source.

Drinking-water consumption pattern versus religions

Figure 11 illustrates the relationship of drinking-water consumption pattern and religions. It was found that religions do not show any significant impact on the choice of drinking water source. All religions preferred tap water, followed by in-home water-treatment device, bottled water and lastly raw water.

CONCLUSION

It can be concluded that most of the respondents preferred tap water as a drinking water source since it is cheap and

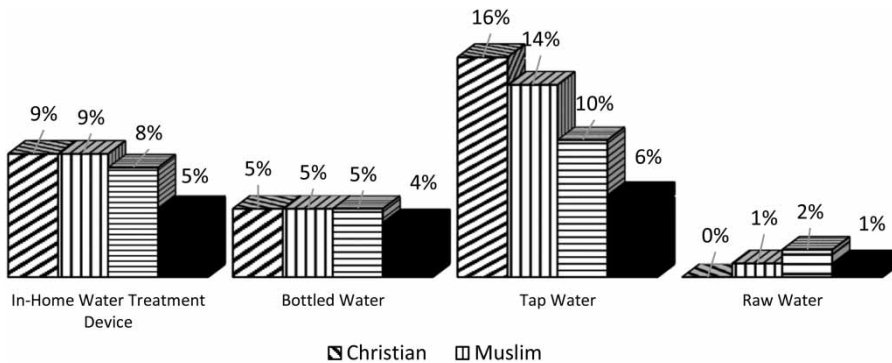


Figure 11 | Drinking water consumption pattern versus religion.

clean, followed by an in-home water-treatment device, bottled water and lastly raw water. In-home water-treatment device is well accepted by higher income group living in urban areas. The selection of bottled water as a drinking water source is always low due to its relatively high price. In contrast, only small group of the respondents consumed raw water. Raw water is not safe to consume due to the presence of viruses and bacteria that may grow inside untreated water, and this can cause sickness.

It was found that demographic factors do affect respondent choice of drinking-water consumption pattern. Respondents staying in urban and suburban areas prefer to use tap filter and in-home water-treatment devices to treat their drinking water. Respondents with higher income tend to have higher living standards, and always initiated the purchase of expensive in-home water-treatment devices for healthier drinking water. Meanwhile, respondents with higher educational level have higher health awareness, tend to pursue better living standards and understand the risk of consuming untreated water. This group always ensures that they will consume from a healthier water source. It is concluded that age, gender and religions do not really affect the selection of drinking water source. Most of the respondents regardless their age, gender and religions preferred tap water as a drinking water source.

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