A Study of Drinking Water Quality for Rural Water Supply in Remote Area

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Abstract
Potable water is the basic need of every human being and everyone has the right to access clean and safe water supply. In Malaysia under Ministry of Health programme, there were 4,878 Gravity Feed System that supply clean water to the rural population and most of systems do not have the element of treatment [1]. Based on the rapid development in general, the systems are vulnerable to the effects of pollution and reduce the water quality. This study was conducted by monitoring the water quality of eight Gravity Feed Systems in eight different villages. Samples were taken from the intake for analysis of microbiological, physical and chemical contamination. In general, the water quality results were below the acceptable level of Drinking Water Quality Standard except E-coli and Turbidity.
Keywords: *Clean and safe water, pollution, rural area, water quality.*

1. Introduction

Humans need portable water to ensure their survival to meet the needs of drinking, food preparation, personal hygiene, clothes and dish washing and the fulfilment of other needs. The World Health Organization (WHO) states it is a human right to have access to sufficient and safe water [2].It is important to provide a significant supply of clean and safe water into households to allow for a better standard of living environment. Although it may be clear and taste fine, it is not considered potable or safe to drink, unless it has passed at certain standards of water quality testing. About 1.6 billion people experience economic water shortage and struggle to secure water for personal and domestic use [3]. According to the WHO also, between 50 and 100 liters of water per person per day are needed to ensure that most basic needs are met and few health concerns arise [2]. Water use recommended by United Nation for Malaysia is 200 litres [4].

Nowadays, potable water can also become contaminated and no longer considered potable or drinkable due to various changes in natural or human actions. More than 80% of diseases that affect humankind are waterborne and most of these diseases can be averted by processing water used for domestic purposes through simple treatment [5]. Globally, pollution of rivers and streams has become one of the most crucial environmental problems of the 20th century. Globally, pollution of rivers and streams has become one of the most crucial environmental problems of the 20th century. Hence, it is important to control water pollution, monitor water quality [6].

In Malaysia the government is giving emphasis on clean water supply, whether in urban or rural areas. For rural water supply, collaboration with Ministry of Rural and Regional Development and Ministry of Health (MOH) actions have been taken to improve the standard living in rural communities as well as safe water quality. MOH under Rural Water Supply and Sanitation (BAKAS) programme is taking part to implement the roles accordingly. There are 5 water supply schemes provided by the Ministry of Health, as follows:

i. Gravity Feed System (GFS)
ii. Well Water System (WWS)
iii. Well Water System with Connection (WWSWC)
iv. Rain Water Collection System (RWCS); and
v. Direct Connection to Public Water Supply (DCPBA)

Gravity Feed system is the most practical solution for rural water supply problems because it only requires simple maintenance costs and relatively low [6]. Generally, if the source is protected from contamination, treatment will not be necessary except for emergency chlorination. There are three factors in this system that can be achieved to stimulate the main objective of BAKAS's programme:

i. To supply safe and clean water to the communities whether it is for an individual, family, group of family, or the whole of society.
ii. The supply of water in sufficient quantity; and
iii. To provide water easy and readily available to the population and to promote hygiene.

Gravity Feed System (GFS) is one of the water supply schemes that comprises of secure catchment areas, damp or tank and piped water supply network. Figure 1.1 portrays the gravity feed system model. Gravity Feed System generally consists of several components, starting from a small dam reinforce concrete structure built on the upper reaches of the stream at an altitude excess of the settlement area. Water from a stream will be carried to the user through a gravity flow system by natural forces through pipelines. This method is suitable for streams and rivers with enough changes in elevation to allow gravity to move the water from the intake to the user or storage tank. Determining the size of the dam and pipe sizes and materials is dependent on local factors. Storage tank construction in the settlements is a choice that depends on the capacity of local water and also the financial resources for a project.

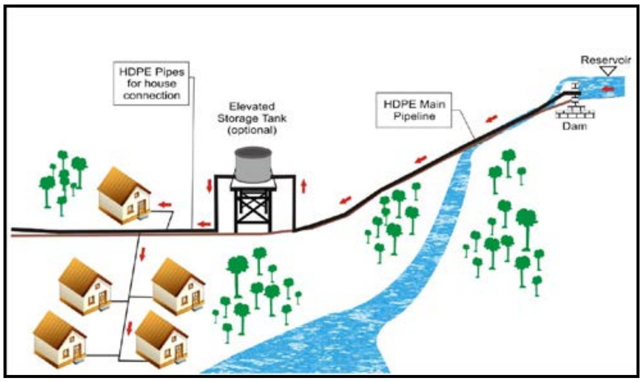

Figure 1.1 Schematic Diagram of Gravity Feed System (GFS) for Rural Water Supply

Most of the systems produce untreated, but wholesome water and therefore the rural people are advised to boil their drinking water. GFS scheme also facing the same issues regarding the deteriorating of water supply quality. The sources of water supply system which were free from pollution at beginning of project, now suffer from deterioration of water quality in general due to rapid development.

The main aim of this study is to improve the health status of the people in rural areas by conducting a study of water quality in rural areas. Scope of the study are focusing on the GFS which were built under BAKAS's programme. Eight GFS in eight different villages of Ingenious People located in the Jelebu District, State of Negeri Sembilan.

2. Benefit of the Study

Analysis on the drinking water quality is necessary to predict the trend of the water quality level as well as to develop a better water resource management plan of GFS for rural communities. It also can be used as very strong basis tools to strategize and plan an optimal management to sustain the system and water quality as a whole.

3. Methodology

Every village has its own Gravity Feed System, which was constructed by the District Health Office of Jelebu, Negeri Sembilan(DHOJ). Each water supply source from the network stream ultimately unites under one flow of major rivers. Supposedly, there is no development and agricultural activities further upstream because the area is gazetted under forest reserve. Due to the natural conditions of the upstream, no treatment is introduced to this system.

The method used to monitor the water quality involved the collection of water samples and measuring the physical characteristics of water on site. Samples collected for microbiological analysis and inorganic chemical analysis were brought to the Lab of DHOJ. A total of 24 water samples were collected on a monthly basis over a period of 3 months based on the sampling schedule and were tested for the following parameters; Microbiological such as total coliform and E-Coli; Physical characteristics such as turbidity, colour, pH, dissolved oxygen, temperature and total dissolved solids; Chemicals such as Ammonia (NH3), Nitrate (NO3), Ferum (Fe), Aluminum (Al), Manganese (Mn), Zink (Zn) and Cooper (Cu).

Sampling points were identified and fixed at 8 locations based on the systems and site condition shown in Table 3.1.

Table 3.1 Details of sampling points

No	Nama of Village	Sampling	Type of Water	Sampling Point Code
1	Tohor	Intake	Untreated	T1, T2, T3
2	Bertam	Intake	Untreated	B1, B2, B3
2	Jeram Lesung	Intake	Partially Treated	JL1, JL2, JL3
4	Dusun Kubur	Intake	Untreated	DK1, DK2, DK3
4	Lakai	Intake	Untreated	L1, L2, L3
6	Banir Tengkoh	Intake	Untreated	BT1, BT2, BT3
7	Ulu Kelaka	Intake	Untreated	UKL1, UK2, UK3
8	Ulu Kemin	Intake	Partially Treated	UKN1,UK2, UK3

4.0 Results and Discussion

The sampling and test results of water quality for raw water samples were recorded over a period of 3 months, based on the sampling schedule.

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4.1 Microbiological Test Results

Figure 4.1 shows that the samples taken from the intake of Banir Tengkoh village have the highest levels of total coliform. However, all of the samples were not exceeding the recommended raw water criteria of 5000 MPN/100mL which has set by The National Guidelines for Drinking Water Quality (NGDWQ) [6]. E-coli contamination was detected as all samples were tested positive for E-coli.

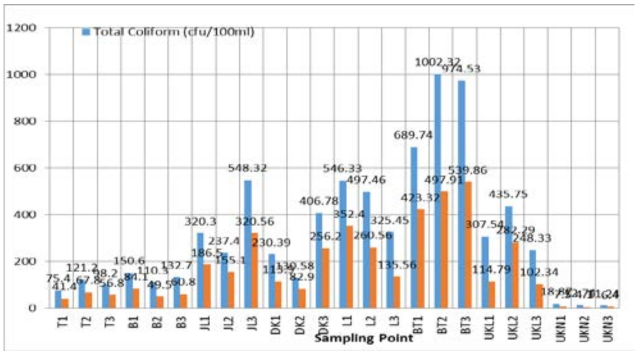

Figure 4.1 Total Coliform and E-coli trends for samples

4.1 Physical Test Results

4.1.1 Turbidity

The recommended raw water criteria and recommended standard for drinking water quality for turbidity is 5 NTU. Because both the GFS systems are used for human consumption, the recommended standard for drinking water quality is used to distinguish between good quality and poor quality of the water. Table 4.2 shows the number of samples that meet the recommended standard for drinking water quality.

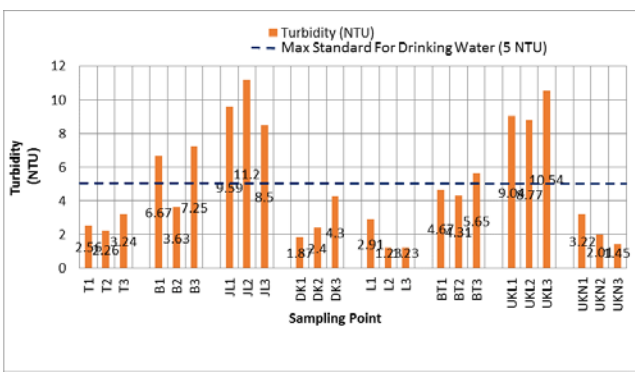

Figure 4.2 Turbidity Trends For Samples

It is apparent from this graph that the bulk of the non-conformance comes from the poor water clarity of Bertam, Jeram Lesung and Ulu Kelaka village. The remaining complies with the recommended standard for drinking water quality where the water has better water clarity.

4.1.2 pH

Figure 4.3 shows the pH values of samples for all the eight villages respectively. The line graph indicates that the pH values of water samples taken were between the range of 6.8 – 7.2. On average, the water is said to be neutral. This range of pH suggests that the source is not polluted by any fertilizer or chemical pollutants.

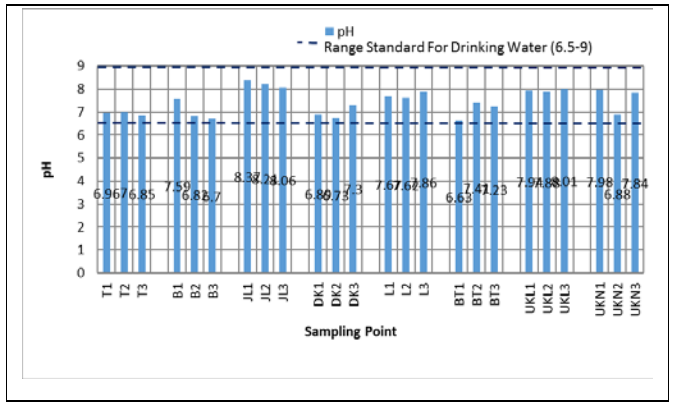

Figure 4.3 pH Trends For Samples

4.13 Colour

With respect to colour, Figure 4.4 shows that all the samples taken do not exceed the recommended standard for drinking water quality of 15 TCU but they have a much better reading than the standard. The highest reading is at the sampling point of Kampung Asli Bertam (1.25 TCU). The presence of colour in the water can reveal physical, chemical and bacteriological conditions. It can be interpreted that overall, the water quality at all the water systems is in a good and satisfactory condition.

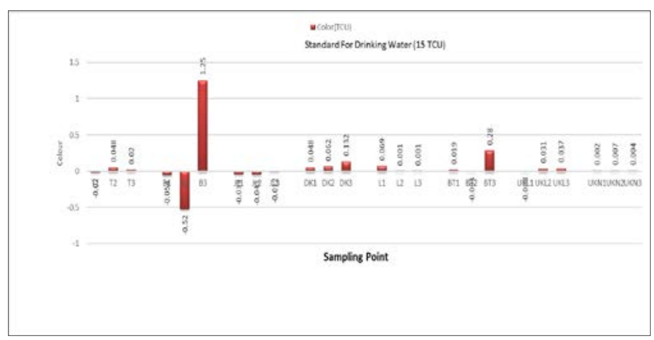

Figure 4.4 Colour Trends For Samples

4.2 Chemical Test Results

4.2.1 Nitrate

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The recommended standard for drinking water quality for nitrate is 10 mg/L. Based on the line graphs in Figure 4.2, none of the samples has nitrate levels higher than the recommended standard. The highest nitrate level is 9.5 mg/L and it was detected at the intake of Bertam village and the second highest was detected at the same location. Rest of samples have lower nitrate levels with all samples having levels below the 5.3 mg/L. This indicates that there are no agricultural activities at the upstream of these intake points that can affect the water quality. However, more observation and study need to be done at the source of water supply in Bertam village, because the two samples result pointed towards the standard limit.

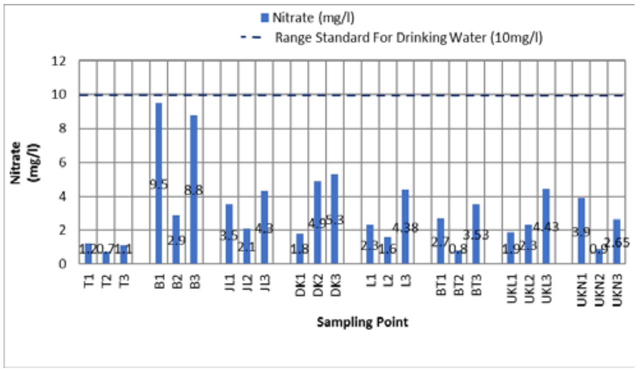

Figure 4.2 Nitrate Trends For Samples

4.2.2 Alumunium

Figure 4.3 shows the Aluminium values of samples for all the eight villages respectively. None of the samples has aluminium levels higher than the recommended standard. The highest aluminium level is 0.076 mg/L and it was detected at the intake of Ulu Kelaka village. As it is known, aluminium low reading indicates it has no signs of pollution that might be caused by dredging soil or logging.

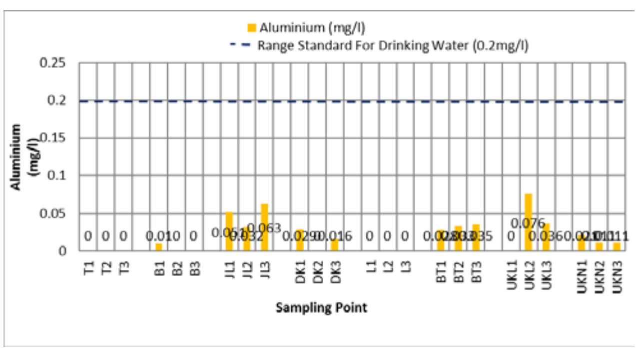

Figure 4.3 Aluminium Trends for Samples

Other chemical parameters such as iron, ammonia, manganese, zinc and cooper all below the permissible level standards.

5.0 Conclusion and Recommendations

Based on the study test results, it is concluded that turbidity is a major contributor to the degradation of water quality impacts at source for the rural area of Jelebu, Negeri Sembilan, Malaysia. About 60% of the overall turbidity complies with the recommended standard for drinking water quality. If the total coliform levels are constantly above the maximum acceptable level, then some form of special treatment would have to be introduced. E-coli contamination was detected as all samples were tested positive for E-coli. Even though the level did not exceed the specified value maximum acceptance level in the NGDWQ, the presence of E-coli indicates that faecal matter is present and it is a cause for concern. For the purpose of drinking and food preparation based on the recommended standard for drinking water of the same guidelines, total coliform and the more specific species of E-coli must not be present. In respect of inorganic chemicals such as ferum, ammonia, nitrate, aluminium, manganese, zinc and copper, all the water supply sources are free from their harmful effects. From the chemical results also, we can conclude the source is not polluted by any fertilizer or chemical pollutants. There are no agricultural activities in the upstream of these intake points that can affect the water quality as there is no signs of pollution that might be caused by dredging soil or logging. Generally, the water quality of both systems is well accepted by the communities.

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