I-GT-082: Assessment of Physico - Chemical Analysis of Ground Water Quality in Rural Area: Kampung Chendrawasih, Pekan Pahang for Drinking Purpose

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Abstract

Groundwater is the main source for Kampung Chendrawasih, Pekan, Pahang as drinking water as well as for agricultural purposes such as bananas, pineapples and paddy. Nevertheless, the water quality of groundwater has been degraded due to existence of heavy metal, high turbidity, biological oxygen demand (BOD), chemical oxygen demand (COD) and colour. Declining water quality is a global issue of concern as it has the greatest impact on public health which lead to various types of diseases such as headaches, nausea and loss of appetite. In this research, the suitability of groundwater quality of a well located in Kampung Chendrawasih, in the district of Pahang state, was assessed for drinking purpose based on the various water quality parameters. Standard methods and techniques of water quality determination for groundwater samples were employed. Based on the assessment result of groundwater samples in Kampung Chendrawasih from various parameters indicated that the groundwater was chemically unsuitable for drinking purpose. Thus, the groundwater from this place needs to be treated and cannot be directly used as drinking water supply. Furthermore, there is still no existing piping system from Pengurusan Air, Pahang (PAIP) provided in this village. Based on the questionnaire conducted by Universiti Malaysia Pahang to the villages, it demonstrated that high demand for clean water from the village residents to purify the existing groundwater supply. From the water quality results, it showed that the quality of Kampung Chendrawasih groundwater can be enhanced by using WASRA treatment system.

1. Introduction

Water is the most essential elements on earth and also called as elixir of life. Water plays the the main role in the wealth of a nation, which is predominantly used by industries and agricultural production. Looking at the global water cycle, the annual fresh water supply gives an average figure of about 7000m^3 per capita (Shiklomanov, 2000). Furthermore, the enhancing growth of population has induced high water demands which leads to increase stress on water resources worldwide. In Malaysia, the population for year 2010 is 28.6 million and it is predicted to rise by 10 million to 38.6 million in 2040 as shown in Figure 1 (Department of Statistics, Malaysia. 2014). Towards the increasing of human population, the main problem faced around the globe is that the per capita of water available will decrease as the amount of fresh water available is limited (Biswas, 1997). Apart from that, water not only supports the needs of the earth but regulate economic life, industry, and agriculture to the growth of a country is estimated that as many as 8% of the raw water source used for everyday use (drinking water, bathing, cooking, and gardening sewage system) and the remaining 22% for industrial use (Yuncong, 2011). Table 1 tabulated the growth of water demand in all states in Malaysia. Utilization of ground water as a water resource is on the alternative way to overcome this issue. Groundwater is pivotal to the domestic water supply system in rural areas, providing a relatively clean, reliable and cost effective resource (Bovolo *et al.*, 2009). Groundwater can be made either by capillary flow from the practice surface or from an aquifers. Furthermore, ground water is the main source for domestic and drinking purposes in both rural and urban areas. Besides, it is also an important source for both industrial and agricultural sectors.

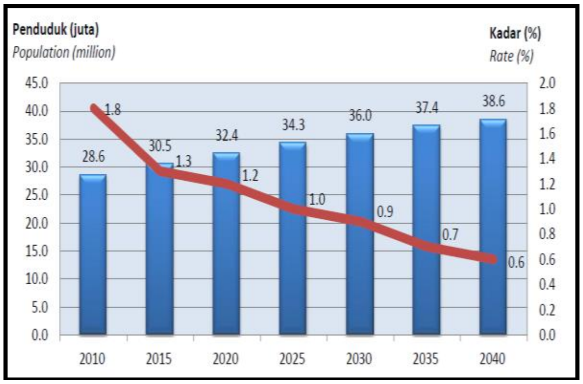

Figure 1: Chart of Population projection and annual population growth rate, Malaysia
Source: Department of Statistics, Malaysia (2014)

Table 1: Statistics of water consumption in Malaysia for year of 2012 and 2013

State	2012					2013				
	Domestic		Non-Domestic		TOTAL	Domestic		Non-Domestic		TOTAL
	MLD	%	MLD	%	MLD	MLD	%	MLD	%	MLD
Johor	769	69.3	341	30.7	1,110	797	68.5	366	31.5	1,163
Kedah	474	74.2	165	25.8	639	487	74.8	164	25.2	651
Kelantan	130	69.2	58	30.8	188	140	69.5	62	30.5	202
Labuan	16[r]	33.8	30[r]	66.2	46	16	34.2	31	65.8	46
Melaka	187	51.7	175	48.3	362	193	51.4	182	48.6	375
N. Sembilan	247	56.3	192	43.7	439	255	54.5	213	45.5	468
Pulau Pinang	475	59.7	321	40.3	796	481	59.5	327	40.5	809
Pahang	287	57.8	209	42.2	496	299	59.3	205	40.7	504
Perak	592	73.1	217	26.9	809	607	72.6	228	27.4	835
Perlis	57	85.5	10	14.5	67	65	81.5	15	18.5	80
Sabah	305	57.6	225	42.4	529	314	59.2	216	40.8	530
Sarawak	432	56.3	336	43.7	768	446	56.4	345	43.6	790
Selangor	1,686	58.3	1,207	41.7	2,893	1,735	58.0	1,254	42.0	2,989
Terengganu	216	55.6	173	44.4	389	230	55.8	183	44.2	413
MALAYSIA	5,873	61.6	3,659	38.4	9,532	6,064	61.5	3,790	38.5	9,854

Source: National Water Service Commission (2014)

The main challenge of the groundwater usage is due to pollutants from various sources. Mostly, ground water can be polluted naturally by the high degree of minerals present in the rocks and soils. Meanwhile, the quality of each ground water may vary from one place to another place. Other than that, industrial and untreated municipal waste, fertilizers, sewers and landfill areas, the rapid population rate are also one of the contributors of ground water pollution. Rural area in Malaysia commonly used ground water as a water sources in their daily life activity without considering any treatment process. Furthermore, the quantity of groundwater is limited that depend on quantity of rainfall and surrounding The average population use aquifer as a source of daily necessities if there is a problem with clean water distribution system by *Pengurusan Air Pahang Berhad* (PAIP) where water was supplied to only certain times, such as midnight. Lack of infrastructure in remote area caused by the imbalance development between the urban and rural areas as activities more concentrated on the development and sustainability of urban areas. However, some of the aquifers are not of adequate exploitable quality due to natural factors or anthropogenic pressures (Epule *et al.*, 2011). Groundwater can have some dissolved forms of chemicals, which may be unacceptable due to their chronic health effects, taste and aesthetic reasons. However, the natural quality of groundwater has progressively deteriorated in many countries due to diverse human impacts (Sankararamakrishan, 2008). Moreover, it is quite expensive to build a water treatment system and allocate water distribution system in rural areas. Since the quality of water is important for mankind and it relates to human welfare, the present study was carried out to assess the ground water quality in Kampung Chendrawasih, Pekan, as groundwater is the only source for drinking, domestic and as well as other purposes in this study area. In order to solve the pollution in ground water, Universiti Malaysia Pahang (UMP) had created a new system which is called WASRA to supply treated and clean water in rural area.

2. Methodology

2.1 Research Area Survey

The site selected was located in Chendrawasih, Sungai Miang, Pekan. Figure 2 shows the view of Kampung Chendrawasih. It is located about 90 km from Universiti Malaysia Pahang, Gambang and takes about 1 hour to reach the village. The village consist of 64 families and mostly work as a construction worker and cultivator in small-scale agriculture. However, there is no source of clean water provided to this village at this moment (Wan Saifulbahri, 2014). The villagers rely on water wells supplied by the Department of Minerals and Geosciences.

Figure 2: View of Kampung Chendrawasih, Pekan

In order to figure out the need for clean water in this area, a total of 30 sets of questionnaires were distributed to the villagers randomly. From the results in Figure 3 and 4, it shows that most of the villagers agreed for WASRA implementation as they are not satisfied with the current ground water quality at Kampung Chendrawasih.

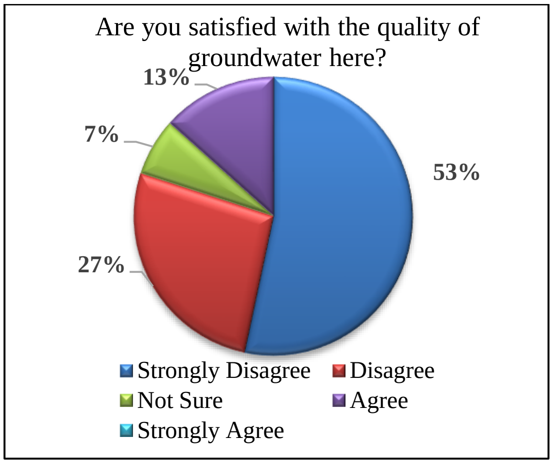

Figure 3: Satisfaction of villagers towards the current water quality in Kampung Chendrawasih

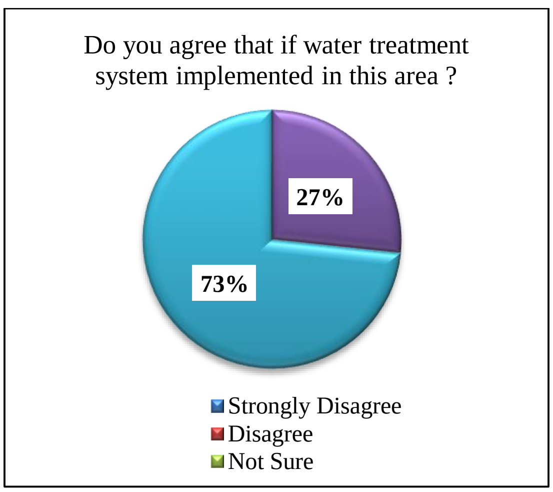

Figure 4: Percentage of villagers agreed for WASRA implementation

More than 60% respondents are not satisfied with the quality of the existing groundwater in this village. According to the villagers, groundwater, which is the main source of water in this village has a bad taste and unpleasant odour that is not suitable to be used as drinking water. This water condition causes few symptoms such as headaches and gastrointestinal related illness such as nausea, diarrhea and vomiting.

2.2 Sample Collection

Water samples collected from the tube well (Figure 5) were kept in polythene containers of two litre capacity for physicochemical analysis after pumping out a sufficient quantity of water from the source. Meanwhile, for bacteriological analysis, samples collected were kept in sterilized glass bottles of 1 litre capacity.

Figure 5: Source of water for Kampung Chendrawasih

3. WASRA System

Water Supply in Rural Area which is also known as WASRA is a water treatment system developed by Universiti Malaysia Pahang researcher. Figure 6 shows the view of WASRA system at Universiti Malaysia Pahang. WASRA system has been created to solve the issue of water quality in ground water in rural areas. It is a new established system to treat ground water and rainwater harvesting by using pre-treatment and membrane filtration processes resulting in safe drinking water before distribute to people living in rural areas. Thus the exposure from groundwater source is commonly in the form of multiple metals and considering the single as exposure does not appropriately represent the health risk of a community (Berglund *et al.,* 2011). Furthermore, this system is more economical and user-friendly. In addition, it is able to eliminate the contaminants that could affect the health and human well-being. This water treatment system process involves four major steps.

Figure 6: View of WASRA System House

Process 1 is a process of extracting raw water which is ground water from the earth's crust using a submersible pump. The ground water reserves depth is 100 meters below the ground and beyond the granite stone (>54 meters). Then, the water will be transferred and stored in a raw water tank with a capacity of 1000 litres. Second step is the pre-treatment process. In this process, it consists of four other processes that are Advanced Oxidation Media, Granular Activated Carbon and Water Softener (Syukor *et al.,* 2014). Ground water stored in a raw water tank is pumped through these columns. Activated Oxidation Media Tank main function is to eliminate contaminants and impurities using oxidation process. Meanwhile, Granular Activated Carbon Tank purpose is to dislodge dissolved substances from water by adsorption mechanisms and the function of Water Softener is to remove hard water as it travels through the hose and effectively remove hardness in water supplies.

The third step involves nanofiltration and ultrafiltration process. After the pre-treatment process, the water was flowing to nanofiltration and ultrafiltration membranes. There are two cylinders on ultrafiltration membrane and one cylinder of nanofiltration in this process (Syukor *et al.,* 2014). Both membranes are functioning to remove particulate matter from the water (Syukor *et al.,* 2009). The last process involves in WASRA system is storage and distribution. After going through process 3, the water will flow to the storage water tank with a capacity of 10 000 litres. Before the water is pumped and distributed to the users, the water was disinfected with chlorine under chlorination process.

4. Physico-Chemical Analysis of Ground Water

The collected samples were analysed for different physical-chemical parameters such as pH, suspended solid, colour, chemical oxygen demand (COD), biological oxygen demand (BOD), fluoride, manganese and from. The testing was conducted at Central Laboratory Universiti Malaysia Pahang. All the results were compared with The Interim National Water Quality Standard (INWQS).

5. Biological Analysis of Ground Water

In terms of biological indicators to assess ground water quality and integrity are based on three parameters. The microbial water quality is based on the detection of E-coli, total Coliforms and faecal Coliforms. The presence of pathogenic organisms and bacteria that contributes to diseases is a concern when considering the safety of drinking water. Pathogenic organisms can cause intestinal infections, dysentery, hepatitis, typhoid fever, cholera, and other illnesses. Therefore, these three parameters have been widely used to evaluate the general quality of water.

6. Results and Discussion

According to the standard quality of water in Malaysia, the Interim National Water Quality Standard (INWQS) (2008), there are six classes for ground water stated in this standard that are Class I, IIA, IIB, III, IV and V. Each categories hold different levels of water content and the uses. As human health is part of this assessment, it is important to identify any harmful substances in water including nano particles that have negative impacts on human health. This is important in order to identify proper ways for elimination and minimization process. Water which is considered safe for humans are usually classified as Class I in which does not requires any treatment while poor quality water lies between Class II and above that requires treatment process.

Table 2 demonstrates the results for untreated ground water and treated ground water using WASRA system at Universiti Malaysia Pahang (UMP) and raw ground water from Kampung Chendrawasih. These three samples were tested based on eleven parameters that includes suspended solid, manganese, fluoride, ferum, color, pH, chemical oxygen demand (COD), biological oxygen demand (BOD), fecal coliforms, total coliform and Escherichia coli (E.Coli). Table 3 and 4 tabulates the Interim National Water Quality Standards for Malaysia (INQWS) (2008) and its uses according to the classes of the water.

Table 2: Results comparison between untreated ground water and treated ground water using WASRA system at UMP and raw ground water from Kampung Chendrawasih

Water Parameter	Untreated Ground Water	Treated Ground water	Raw Ground Water Kg. Chendrawasih
COD (mg/L)	25.63	11.00	46.00
BOD (mg/L)	5.39	0.84	11.00
Suspended Solid (mg/L)	23.93	0.00	1.00
pH	6.91	6.53	6.00
Color (TCU)	87.80	9.17	35.00
Fluoride	1.74	0.02	0.46

(mg/L)			
Ferum (mg/L)	0.88	0.00	0.30
Manganese (mg/L)	0.38	0.00	Not Detected
Total Coliform (counts/100ml)	-	-	-
E-coli (counts/100ml)	-	-	-
Fecal Coliform (counts/100ml)	-	-	-

Table 3: Interim National Water Quality Standards for Malaysia (INQWS)

Water Parameter	Classes					
	I	IIA	IIB	III	IV	V
COD (mg/L)	10	25	25	50	100	>100
BOD (mg/L)	1	3	3	6	12	>12
Suspended Solid (mg/L)	25	50	50	150	300	>300
pH	6.5-8.5	6.5-9.5	6-9	5-9	5-9	-
Color (TCU)	15	150	150	-	-	-
Fluoride (mg/L)	<1.5	1.5	1.5	10	1	>1
Ferum (mg/L)	<1	1	1	1	1	>1
Manganese (mg/L)	-	-	-	-	-	-
Total Coliform (counts/100 ml)	100	5000	50 000	50 000	50 000	> 50 000
Fecal Coliform (counts/100 ml)	10	100	400	5000	5000	-

Table 4: Water uses according to classes

Classes	Uses
I	Conservation of natural environment Water Supply 1- Practically no treatment necessary Fishery I- Very sensitive aquatic species
IIA	Water Supply II - Conventional treatment. Fishery II - Sensitive aquatic species.
IIB	Recreational use body contact.
III	Water Supply III- Extensive treatment required. Fishery III– Common of economic value and tolerant species, livestock drinking.
IV	Irrigation
V	None of the above

Based on Table 2, untreated ground water of UMP shows that COD, BOD and fluoride value is classified as CLASS II which required conventional treatment to ensure the water is safe to be used. High level of COD in water will significantly decrease the amount of dissolved oxygen available for aquatic organisms. Meanwhile, high levels of BOD value lead to an increment of anaerobic bacteria and high level of fluoride can give the effects to fluorosis. After UMP ground water was treated by using WASRA system, all the parameters, manage to achieve Class I except for COD that remain in CLASS II. Therefore, by using WASRA system, it shows great improvement in terms of water quality as untreated ground water in UMP are classified in Class II and III. As compared to raw ground water from Kampung Chendrawasih, most of the parameters are categorized in Class II and III which is same with the untreated water before using WASRA system. Therefore, WASRA system has the ability to treat the raw ground water to achieved Class I. When the treated water achieved the standard of Class I, the water can be used for drinking and others purposes in human activity life.

7. Conclusion

As a conclusion WASRA, based on the data gathered, this system has the ability to treat the raw ground water from Kampung Chendrawasih as the parameters were similar with those of the untreated water at Universiti Malaysia Pahang, before treatment with WASRA. Therefore, it is believed that this system will be able to solve the ground water issue, so the residents of the village will live more comfortable lives, with access to clean water. This effort also supports Malaysian Vision 2020 to be a fully developed nation by the year 2020.

Acknowledgment

The authors would like to express their acknowledgement to the financial assistance from Universiti Malaysia Pahang, under research grant RDU 141010 and sincere appreciation to the many individuals who have offered support, inspiration, and encouragement throughout this project.

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