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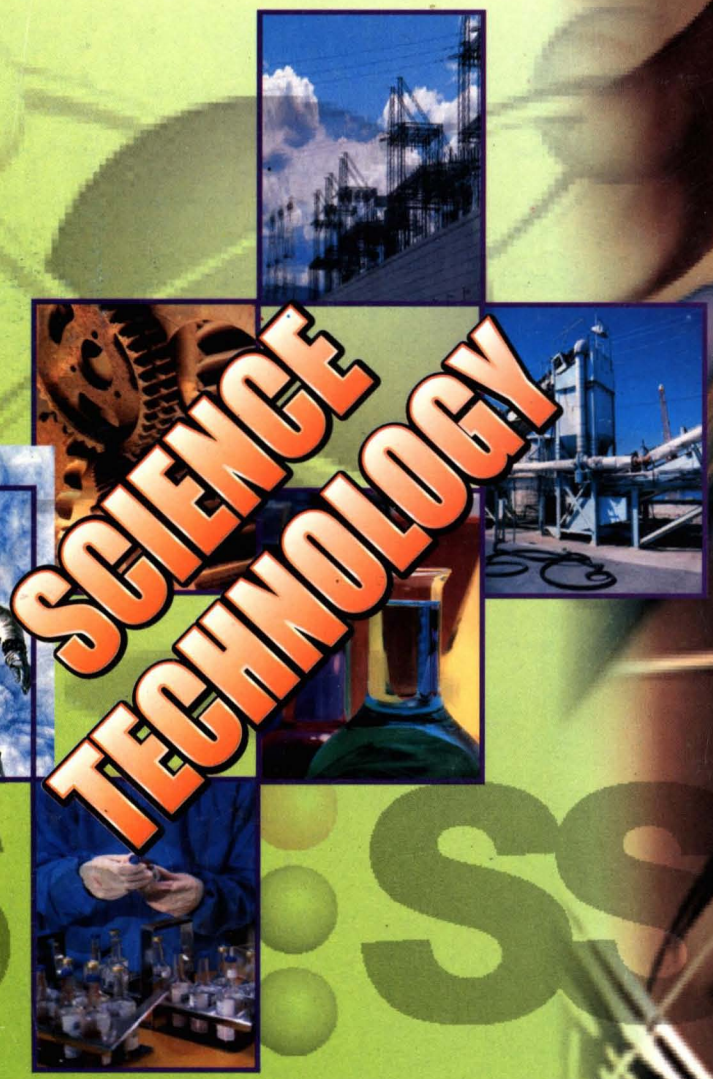

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Study on Well Water Quality in North-Eastern Kelantan

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ABSTRACT

In the north-eastern districts of state of Kelantan almost 40% of the populations are still relying on well water for their domestic uses and consumption. Generally, the wells are located within the vicinity of agricultural activities, such as tobacco, paddy, rubber plantations and orchards. Thus, there is possibility that these activities, especially application of fertilizers, may pollute the wells. A study was carried out on thirty wells in the districts of Bachok and Pasir Puteh to determine the well-water quality as well as the nitrate, phosphate, sulphate and chlorine ion contents of the water samples. The sampling was done twice in July and August 2005. Data for salinity, turbidity, temperature, DO, pH and conductivity were determined in-situ, while minerals contents, BOD and COD were determined in laboratory. Water Quality Index (WQI) of the samples was determined based on the method suggested by Interim Water Quality Standards (INWQS) for Malaysia. In general, WQI in all the wells studied for the two sampling dates fall into class III, slightly polluted category. Based on the INWQS, these classes of water required extensive treatment before being used as public water supply. The study was also extended to the investigation on the presence of coliform bacteria in the water samples.

Keywords: *Well-water, WQI, cataion contents, coliform*

Introduction

In line with the increasing awareness on the importance of good health among Malaysians, drinking water quality is becoming an increasing debating subject and important issue in Malaysia. (Pillay and Talha 2003; Murali 2005). Demand for good quality water is ever increasing. The global demand in water consumption has doubled since 1940 and is expected to double again within twenty years (Karr *et al.* 1995). With this kind of demand and the inability of the relevant authorities to supply processed cleaned water, majority of people in less developed areas resort to consuming untreated well-water.

The majority of people living in these less developed areas are involved in agriculture and farming activities. Each year they apply increasing amount of chemical fertilizers to their field in order to obtain higher yields and faster growing crops. Excess fertilizer containing phosphates and nitrates will eventually find ways into pools, ponds and wells (Barber, Beneke and Breedlove 2002; Hooda *et al.* 2000). Beside fertilizers, phosphate salts used in detergents could also contribute to phosphate accumulation in well-water. Animal wastes also contributed to phosphate and nitrate in runoff water (Gymer 1977).

Phosphate and nitrate are nutrients for plant growth. However, they can also be the primary cause of well enrichment leading to the growth of algae and weeds. This process is known as eutrophication. The presence of algae and weeds will affect the water quality index. In fact the presence of 10 ppm nitrate-nitrogen in drinking water can cause methemoglobinemia (inability to use oxygen) in infants (Rosen and White 1999), and other health related risks may happen at higher concentration (NECi 2000). Thus, the reason to be concern about here is the concentration of phosphate and nitrate in water.

Although the presence of nitrate and phosphate in groundwater in agricultural areas has become the main concern in various countries (Gymer 1977; Rosen and White 1999; NECi 2000), not many study has been carried out in Malaysia. Since many households in agricultural areas in Malaysia still utilize untreated well water for their drinking and other domestic purposes, it is interesting to study the concentrations of phosphate and nitrate in well water and their relation to the water quality index.

Methodology

Sampling Areas and Sampling

The study covered two districts, Bachok and Pasir Puteh in Kelantan. Water sample were collected from fifteen wells. The depths of the wells ranged between 30 to 40 feet. However, the water volume in each well depends on

various factors, such as season, location from river, height (elevation) from sea level. In general, water volume increases during rainy season. Table 1 summarises the well location, usage and type of plantation around the wells. Majority of the wells were used as drinking water and other domestic usage such as washing, bathing and cooking.

Table 1: Sampling wells, usage and type of plantation

District	Area	Code	Usage	Plantation
Pasir Puteh	Kg. Jelor	**PP1**	Domestic	Orchard
	Kg. Jelor	**PP2**	Domestic, drinking	Orchard
	Kg. Jelor	**PP3**	Domestic	Rubber
	Kg. Tasek Pauh	**PP4**	Domestic	Paddy
	Kg. Tualang Tinggi	**PP5**	Domestic, drinking	Orchard
Bachok	Kg. Keting	**B1**	Domestic	Paddy
(Gunung)	Kg. Keting	**B2**	Domestic, drinking	Orchard, paddy
	Kg. Pauh Gutut	**B3**	Domestic, drinking	Orchard
Bachok	Kg. Pdg. Kerasak	**BM1**	Domestic, drinking	Tobacco
(Melawi)	Kg. Pantai Baru	**BM2**	Domestic, drinking	Coconut
	Kg. Pantai Baru	**BM3**	Domestic, drinking	Orchard
	Kg. Pantai Baru	**BM4**	Domestic, drinking	Orchard
Bachok	Kg. Bator	**BJ1**	Domestic, drinking	Paddy
(Jelawat)	Kg. Bator	**BJ2**	Domestic	Orchard
	Kg. Bator	**BJ3**	Domestic, drinking	Orchard

Sampling was carried out twice, one on 23rd July and another on 26th August 2005. Water samples were collected using *'water theft'* coupled to a 1-liter plastic sample container, at a point of about 15 cm from surface. The plastic container was first rinsed with the respective well-water before being used in the collection procedures. Water sample in the containers are kept in close cooler box at ice temperature, before being transported to the chemical analysis laboratory. While in the laboratory, the samples were kept at 4°C until further analysis.

Analysis

In-situ analysis was carried out using portable monitor to determine water samples' temperature, pH, electric conductivity (EC), dissolved oxygen (DO) and turbidity. Other parameters and cations concentration were determined in laboratory using methods described in Table 2. The Water Quality Index (WQI) was calculated using the method used by Mohd Talib Hj Latiff (2004), based on the formula suggested by the Department of Environment, Malaysia (JAS 1991). In the laboratory the water was tested for the presence of coliform bacteria. Bacteria count was performed using the haemocytometer. Pour plate method was carried out prior to the Gram-stain method to culture and observe single bacteria colonies. The latter method was to distinguish the Gram-positive and Gram-negative bacteria.

Table 2: Methods used for analysis of water samples

Parameter/Ions	Instruments and Method
Nitrate	HACH quick programme 355, DR 2000 Spectrometer
Phosphate	HANNA Phosphate High Range ISM, HR HI 93717
pH	Portable pH meter, model WP-81, TPS
Temperature, °C	Portable Temperature meter, model WP-81, TPS
Dissolved Oxygen (DO), mg/l	HANNA portable DO probe
Turbidity, NTU	HANNA portable turbidity meter
Total Suspended Solid (TSS), mg/l	Total non-filterable residue, dried at 103 – 105 °C, using Whatmann GF/C filter
Chemical Oxygen Demand (COD), mg/l	Digestion. COD Reactor MERCK TR-420. Measured using HACH DR 2010 Spectrometer
Biochemical Oxygen Demand (BOD), mg/l	HACH BOD track sample and HACH incubator
N-NH_3, mg/l	HACH quick programme 380, coupled to HACH DR 2000 Spectrometer
Cl^-, mg/l	Argentometric method
SO_4^{2-}, mg/l	Sulfaver 4 method. HACH program 680, DR2500 Spectrometer

Results and Discussion

Water Quality

Table 3 lists down results for the six parameters used in the determination of the WQI values. In the table results for both the first and second sampling were shown. For both samplings only results for NH_3-N concentration and total suspended solid (TSS) for all the wells studied fall into Class I based on the Interim National Water Quality Standard (INQWS). For dissolved oxygen (DO), depending on the concentration, based on the INQWS they fall into between Class III and Class V. As for chemical oxygen demand (COD), all the wells during both samplings show that they fall into Class II and Class III. However, for biochemical oxygen demand (BOD) the same results were observed for the first sampling, but the class deteriorates to fall into between Class II and Class V during the second sampling. The pH values for samples collected show that the well water samples are acidic except for samples from BM1, BM2, BM3 and BM4. For these for sampling points the pH values are more than 7.0. This could be attributed that the locations of BM1, BM2, BM3 and BM4 are in very close vicinity to the sea. The class categories for pH fall into between Class I and Class III.

In Table 3, the Water Quality Index (WQI) values for all the wells during both sampling are also shown. The values were calculated using WQI formula by employing the appropriate sub-index values for the six parameters in the table. The values ranged between 57.8 (B3 during second sampling) and 73.2 (BM2 during the first sampling). According to the general rating scale, samples with WQI values of less than 60 is rated as very polluted and need necessary treatment. Generally, the samples falls into slightly polluted rating in Class III since their WQI values falls between 60 and 80. For Class III water supply, extensive treatment is required before being considered suitable for drinking.

Table 3: Results for WQI parameters, WQI Values and Class for the well water studied

	#	DO (mg/l)	BOD (mg/l)	COD (mg/l)	NH_3-N (mg/l)	TSS (mg/l)	pH	WQI	Class
PP1	1	2.3	2.3	28	0.02	19.9	6.6	67.9	III
	2	3.1	9.0	30	0	5.5	6.5	64.2	III
PP2	1	1.9	5.0	31	0	1.5	5.7	65.7	III
	2	1.7	5.0	32	0	0.8	5.7	65.6	III
PP3	1	1.8	2.0	27	0	3.4	5.7	68.8	III
	2	2.1	7.0	21	0	8.2	5.9	66.1	III
PP4	1	2.7	2.6	25	0	9.5	6.1	68.8	III
	2	3.0	2.4	22	0	3.3	6.3	70.4	III
PP5	1	1.4	6.0	21	0.02	5.0	6.2	67.4	III
	2	1.3	13.0	31	0.02	3.7	6.1	60.5	III
B1	1	2.0	10.0	33	0.02	8.8	6.1	61.9	III
	2	1.9	2.0	25	0	12.8	6.2	69.1	III
B2	1	1.5	2.0	34	0	2.5	5.8	67.8	III
	2	1.6	1.4	33	0	2.3	5.7	68.3	III
B3	1	2.6	5.0	34	0	0.2	5.8	65.6	III
	2	2.3	18.0	35	0	1.5	5.9	57.8	III
BM1	1	1.5	2.6	13	0.01	9.3	7.2	71.6	III
	2	2.6	1.4	16	0	6.1	7.5	72.7	III
BM2	1	3.0	2.1	11	0	0.7	7.4	73.2	III
	2	4.0	2.8	21	0	3.1	7.3	70.7	III
BM3	1	2.4	2.0	21	0.01	0.7	7.6	71.2	III
	2	3.9	3.2	21	0.01	0.9	7.6	70.2	III
BM4	1	3.8	0.7	28	0.01	0.8	7.6	70.9	III
	2	1.3	1.5	31	0	13.3	6.9	69.2	III
BJ1	1	1.1	9.0	29	0	11.8	6.6	63.8	III
	2	1.7	12.0	30	0.02	8.6	6.4	61.5	III
BJ2	1	1.2	7.0	16	0.01	5.3	6.0	67.1	III
	2	1.4	14.0	16	0	7.9	6.0	62.4	III
BJ3	1	1.8	3.0	24	0	3.0	5.6	68.6	III
	2	2.4	6.0	25	0	1.8	5.9	66.7	III

Other Parameters

In Table 4 below, results of other parameters determined in the present study are shown. All samples studied were physically clear, thus explain the low turbidity obtained. All turbidity values are classified under Class I since the values are below 50 NTU. For nitrate, except for sample from PP1, all concentrations are below 10 mg/l. The concentrations for PP1 are 11.2 mg/l and 11.1 mg/l for the first and second sampling respectively. According to Food Act 1983 (ACT 281) and Regulations, the standard limit for nitrate concentration in water is 10 mg/l.

Table 4: Results for turbidity and cation concentration of the well water studied

	#	Turbidity (NTU)	PO_4^{3-} (mg/l)	NO_3^- (mg/l)	SO_4^{2-} (mg/l)	Cl^- (mg/l)
PP1	1	4.6	2.5	11.2	21	8.0
	2	2.7	3.2	11.1	23	4.5
PP2	1	2.2	3.8	1.4	30	11.4
	2	1.8	6.1	1.5	29	4.9
PP3	1	4.3	1.2	2.2	7	4.2
	2	2.4	5.8	1.9	11	3.6
PP4	1	28.0	2.0	1.0	45	8.0
	2	0.4	3.6	2.4	42	2.7
PP5	1	11.6	1.0	2.2	9	6.8
	2	0.2	3.9	1.7	6	5.5
B1	1	14.0	2.2	1.7	1	4.3
	2	12.9	3.9	1.4	2	3.0
B2	1	0.7	2.8	1.3	9	5.0
	2	0.1	1.5	1.6	9	4.7
B3	1	1.9	2.0	2.9	0	3.3
	2	1.8	0.9	3.3	0	3.1
BM1	1	31.0	4.3	1.0	47	10.1
	2	2.5	2.4	1.4	49	23.5
BM2	1	2.7	1.3	1.8	2	9.3
	2	2.4	5.6	1.3	5	8.2
BM3	1	-	1.5	1.5	35	10.1
	2	1.8	6.4	1.5	28	5.2
BM4	1	0.5	1.8	2.1	22	10.6
	2	2.2	1.0	1.5	24	2.9
BJ1	1	21.0	2.2	1.8	22	9.4
	2	0.2	6.6	2.4	24	7.9
BJ2	1	2.0	0.5	2.1	27	8.7
	2	7.5	7.6	3.8	28	8.0
BJ3	1	-	1.7	1.7	7	3.3
	2	0.08	3.2	2.3	4	2.8

Phosphate concentration is another water quality parameter of interest in the present study. Results showed that the concentration varies between 0.5 to 4.3 mg/l during the first sampling and between 0.9 to 7.9 mg/l during the second sampling. Generally, phosphate concentrations are higher in samples during the second sampling. This may be attributed to the fact that phosphate ion is soluble in water, and may seep through into the wells with the rain water, since it was raining a day before the second sampling.

Sulphate was not detected in B3 for both sampling. However for other water samples the concentration varies up to 47.0 mg/l and 49.0 mg/l for the first and second sampling respectively. The highest concentration was for water samples from BM1. These concentrations are below the suggested INWQS standard value of 400 mg/l (JAS 1991).

The highest concentration of chloride, 23.5 mg/l was observed for water sample from BM1 during the second sampling. In general, samples from BM1, BM2, BM3 and BM4 show relatively higher concentration of chloride as compared to other samples. This might be due to the fact that these wells are located close to the sea, and underground seeping of sea water that contained chloride into the wells might have taken place. However, the concentrations are much below 250 mg/l that might cause saltiness to the well water.

Table 5: Types and bacteria count in respective water samples

	Appearance of nutrient broth after 24 hours incubation at 37°C	Appearance / number of colonies in nutrient agar after 24 hours incubation at 37°C	Results from Gram staining	Conclusion
PP1	cloudy	98 colonies	red, rod shape	Gram negative bacilli
PP2	clear	1 colony	purple, rod shape	Gram positive baccili
PP3	cloudy	52 colonies	red, rod shape	Gram negative baccili
PP4	cloudy	45 colonies	red, rod shape	Gram negative baccili
PP5	clear	1 colony	colony deep in agar	Not conclusive
B1	cloudy	17 colonies	red, rod shape	Gram negative baccili
B2	cloudy	2 colonies	red, rod shape	Gram negative baccili
B3	cloudy	3 colonies	red, rod shape	Gram negative baccili
BM1	clear	None	Not done	No bacteria detected / Free from bacteria
BM2	cloudy	13 colonies	red, rod shape	Gram negative baccili
BM3	cloudy	40 colonies with big patches	purple, rod shape	Gram positive baccili
BM4	cloudy	500 very small colonies	red, rod shape	Gram negative baccili
BJ1	cloudy	75 colonies with big patches	colony: purple, rod;	Gram positive and Gram negative bacilli
BJ2	cloudy	64 colonies	red, rod shape	Gram negative baccili
BJ3	cloudy	4 colonies	purple, round shape	Gram positive cocci

Bacteria

Results of the study on bacteria in the well water samples showed the presence of bacteria in all samples, except samples PP5 and BM1, as shown in Table 5. Two types of bacteria, gram negative baccili and gram positive baccili were present in the samples. Although at the end of the study many samples showed the presence of few colonies of bacteria, sample BM4 show the presence of up to 500 small colonies of bacteria.

Conclusion

In general, the study has shown that the WQI of all the wells studied are above 50, and that need further extensive treatment before can be regarded suitable as water supply based on the INWQS index and classification. The low DO level and high COD and BOD are the main contributing factors attributed to the classification of the well water samples into Class III. The nitrate and phosphate contents of all the samples studied are still below the suggested limit, indicating the effect of fertilizers on the wall water is minimal. Other parameters and cations concentration are still below the standard limits.

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