LAPORAN AKHIR PENYELIDIKAN YANG BERTAJUK " A STUDY ON THE POTABILITY OF RURAL WATER SYSTEMS IN TANAH MERAH AND PASIR PUTEH DISTRICTS, KELANTAN"

OLEH **DR. SHARIFAH MAHANI BT SYED MAHAR AFFANDI**

JABATAN PERUBATAN MASYARAKAT

SHORT TERM RESEARCH GRANT **304/ PPSP/ 6131127**

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KANDUNGAN

1. **PENULISAN DISERTASI**
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A STUDY ON THE POTABILITY OF RURAL WATER SYSTEMS IN TANAH MERAH AND PASIR PUTEH DISTRICTS, KELANTAN

BY

DR. SHARIFAH MAHANI BT SYED MAHAR AFFANDI

Dissertation Submitted In Partial Fulfilment Of The Requirements For The Degree Of Master Of Community Medicine (Environmental Health)

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AKSB	~	Air Kelantan Sdn Bhd.
BAKAS	~	Bekalan Air dan Kebersihan Alam Sekeliling
DC	~	Direct Connection
DR 2000	~	Direct Reading Spectrofotometer
FRC	~	Free Residual Chlorine
GFS	~	Gravity Feed System
KMAM	~	Kawalan Mutu Air Minum
MOH	~	Ministry of Health
NDWQMSP	~	National Drinking Water Quality Monitoring and Surveillance Programme
OHT	~	Over Head Tank
PHI	~	Public Health Inspector
TDS	~	Total Dissolved Solid
USM	~	Universiti Sains Malaysia
WHO	~	World Health Organization

ABSTRACT

BAKAS (Water supply and environmental sanitation) unit of Ministry of Health was first introduced in 1974 for controlling water and vector borne diseases by providing safe water supply and sanitation facilities for rural areas. A cross-sectional study was conducted to study the potability of rural water systems such as Gravity Feed System (GFS), Over Head Tank (OHT), Direct Connection (DC) and Air Kelantan Sdn. Bhd. (AKSB) water connections supplies by BAKAS unit in Tanah Merah and Pasir Puteh, Kelantan. A total of 325 households from different villages were selected using multistage random sampling. Data were collected using 3 methods; interviewed using structured questionnaire regarding the consumer satisfaction on the quality and the quantity of the rural water supply, water sampling for physical, chemical and microbiology, and sanitary survey to estimate the risk of water contamination. The results of the water analysis were compared with the permissible level from Ministry of Health Malaysia. Parameters that have violations are, presence *E.Coli* (54.3%), pH (55.2%), colour (2.5%), turbidity (29.3%), free residual chlorine (86.7%), ammonia (3.7%), iron (3.7%) and phosphate (16.7%). No violation found in conductivity, total hardness, total dissolved solid, sulphate and nitrate in all water samples. Results also shows that the most unpotable rural water system is the GFS in which all the samples taken are contaminated with *E.coli*. Comparing the 2 types of well system, OHT are better than DC. The most potable water system is AKSB water connection in which only 3.8% are contaminated. Majority of the consumer (75.3%) are very satisfied with the water system although 66.2

% are still complaining of not enough water supply. This is one of the worrying situations because they used alternative water sources that are usually not safe and not monitored by the MOH. Sanitary survey showed that GFS is more at risk for contamination compared with OHT and DC. Thus the water potability in Tanah Merah and Pasir Puteh is still not very satisfactory. The condition could be improved by community participation in all aspects of water supply and sanitation schemes including planning, design, construction, operation and maintenance the BAKAS projects. Health education on good personal hygiene also can help in preventing the water–borne diseases.

ABSTRAK

KAJIAN POTABILITI SISTEM BEKALAN AIR LUAR BANDAR DI DAERAH TANAH MERAH DAN PASIR PUTEH, KELANTAN

Unit BAKAS (Bekalan Air dan Kebersihan Alam Sekeliling) Kementerian Kesihatan Malaysia mula diwujudkan pada tahun 1974 untuk mengawal penyakit bawaan air dan vektor melalui pembekalan air minum yang selamat dan kemudahan kebersihan di luar bandar. Kajian hirisan lintang telah dijalankan untuk mengetahui tentang potabiliti berbagai sistem bekalan air yang disediakan oleh unit BAKAS seperti sistem air bukit, telaga tiub dengan tangki, telaga terbuka tanpa tangki dan juga lain-lain sistem seperti sambungan air AKSB. Kampung-kampung luar bandar yang terpilih sebagai kawasan kajian adalah terletak di daerah Tanah Merah dan Pasir Puteh selepas melakukan kaedah persampelan rawak berperingkat. Sejumlah 325 rumah pengguna terpilih dimana 82 rumah dari GFS, 80 rumah dari OHT, 84 rumah dari DC dan 79 rumah dari AKSB. Data dikumpulkan melalui 3 cara iaitu dengan temuramah pengguna menggunakan soalan berstruktur berkenaan dengan kepuasan pengguna tentang kualiti dan kuantiti bekalan air yang dibekalkan, analisa mutu contoh air dari segi mikrobiologi, fizikal dan kimia, dan kajian kebersihan ke atas setiap sistem air untuk menentukan tahap risiko untuk dikontaminasi. Keputusan analisa contoh air akan dibandingkan dengan paras yang dibenarkan dari Kementerian Kesihatan Malaysia. Parameter yang didapati melanggar piawai adalah kewujudan *E.Coli* (54.3%), pH (55.2%), warna (2.5%), kekeruhan (29.3%), baki bebas klorin (86.7%), ammonia (3.7%), iron (3.7%) and phosphat (16.7%).

Tiada perlanggaran bagi konduktiviti, jumlah keliatan air, jumlah pepejal terlarut, sulfat and nitrat dalam semua contoh air dari keempat-empat sistem air luar bandar. Keputusan kajian juga menunjukkan bahawa sumber air GFS merupakan sistem air yang paling tidak potabel dimana semua contoh air yang diambil adalah mengandungi *E.coli*. Sambungan air AKSB pula merupakan bekalan air yang paling potabel dimana hanya 3.8% contoh air adalah positif dengan E.*coli*. Dibanding tahap potabiliti dari 2 buah sistem telaga, OHT adalah lebih baik dari DC. Pada keseluruhannya, 75.3% pelanggan adalah sangat berpuashati dengan kualiti air minum tetapi masih terdapat 66.2 % mengalami masalah kekurangan bekalan air yang tidak menentu. Ini merupakan salah satu masalah besar kerana mereka ini akan menggunakan sumber air alternatif yang biasanya tidak bersih dan tidak dikawal oleh Kementerian Kesihatan. Kajian kebersihan menunjukkan GFS adalah lebih terdedah kepada kontaminasi yang teruk berbanding sistem OHT dan DC. Pada kesimpulannya, potabiliti sistem air luar bandar yang dibekalkan oleh unit BAKAS di Tanah Merah dan Pasir Puteh adalah masih tidak memuaskan Keadaan ini boleh diperbaiki dengan kerjasama dari masyarakat setempat dalam kerja –kerja yang berkaitan dengan bekalan air bersih dan juga kemudahan kebersihan termasuklah diperingkat perancangan, pembinaan, operasi dan penyelenggaran sesuatu projek. Pendidikan kesihatan tentang amalan kebersihan diri yang baik turut membantu dalam menghalang penyakit bawaan air dari merebak.

CHAPTER ONE

INTRODUCTION

Water is an essential nutrient. Each person drinks an average of 2.0 litres of fluids daily, depending on body size, body metabolism, physical activity and environmental conditions. Potable water in Malaysia should be a public water supply that meets the National Guidelines for Drinking Water Quality, with respect to its physical, chemical and microbiological characteristics (WHO, 2000). Thus, the quality and the potability of water is very important, as contaminated water may cause food and water–borne diseases, skin and eyes disorders and other organ problems (Shukur, 1997). The provision of effective sanitation programmes and access to safe drinking water has been major problems for many developing countries.

Water quality was recognized as the foundation for any health improvement strategy, accompanied by programmes for increased water quantity and sanitation. However, in the absence of changes in personal behaviour and hygiene practices, the incidence of water-related diseases, especially diarrhoeal illness, is likely to remain high in contaminated environments, where the faecal-oral route is a major source of disease transmission (Kravitz *et al.*, 1999). The challenges confronting the water supply sector in Malaysia is not only to ensure adequate and continuous water supply to all residents but also to ensure that it is able to meet the ever more stringent water quality standards consistently (Tan, 1997). The provision of good quality water is considered an important preventive health measures, as this is directly responsible for the reduction in the incidence of many of the common water-borne diseases such as cholera, typhoid, dysentery and viral hepatitis (Sugunan, 1983).

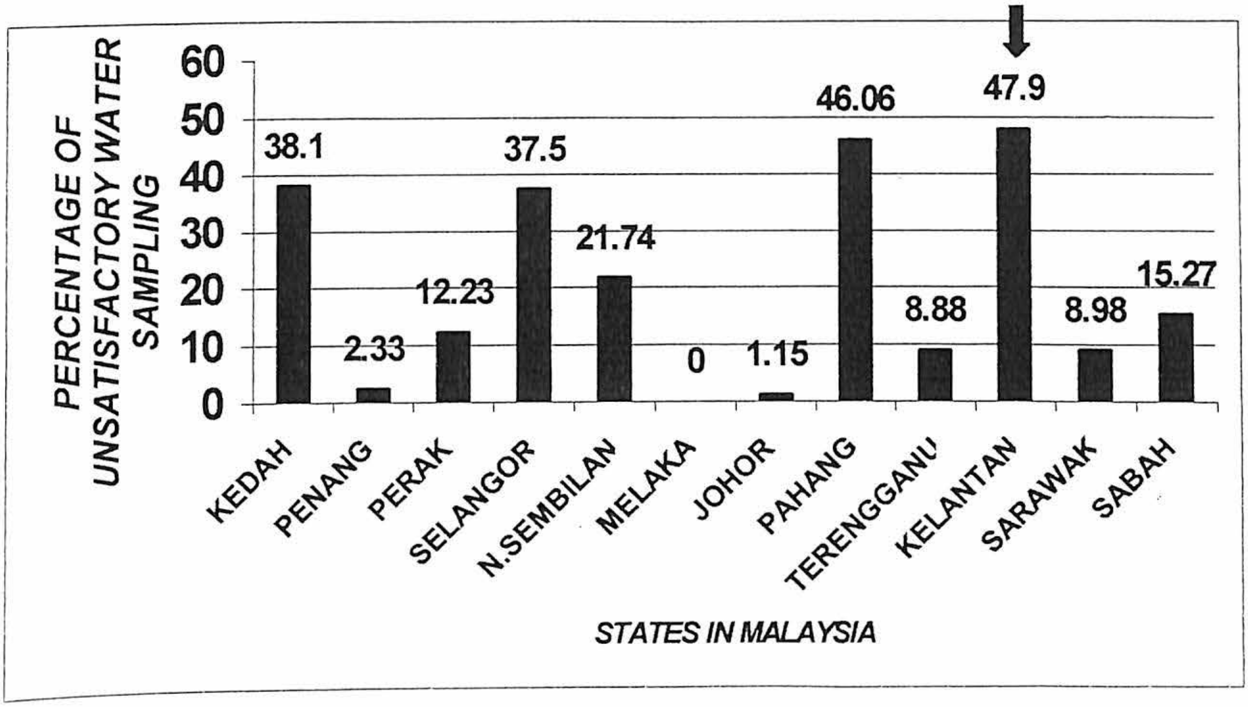
1.1: Why rural water system?

According to WHO in 1998, more than 1 billion people do not have ready access to an adequate and safe water supply, and a variety of physical, chemical and biological agents render many water sources unhealthy. More than 800 million of those unserved live in rural areas. Urban areas generally have higher coverage than rural areas. In cities, water is often provided to districts whose populations can pay for services (WHO, 1998). The monitoring of drinking water quality in Malaysia has been going on for more than 50 years as an important component of the Health Service Program and was implemented by the respective District Health Offices in Malaysia. However, the program that existed was not effectively carried out throughout the country and only takes the routine sampling and filing away the results of laboratory analyses, with little follow-up and corrective action (Sugunan, 1983). The Ministry of Health only monitored regularly the quality of treated water from treatment plant and not from rural water systems and the success of implementation is still questionable.

Figure 1 showed that Kelantan had the highest percentage (47.9%) of unsatisfactory (not potable) water samples from rural BAKAS project in 1999. The 1980s was the

International Water Supply and Sanitation Decade (IDWSSD). The goal was to improve health through national and international collaborative efforts by the development of self-reliant and sustainable safe community water supply and sanitation programmes for all by 1990. The main target was rural and urban unserved populations.

Figure 1: Percentage of unsatisfactory (not potable) water sampling from MOH project by state in 1999.



Source: Engineering Division of Environmental Health Unit, MOH, 2000.

In 1983, with the assistance of WHO, the national drinking water quality monitoring and surveillance programme was given a face–lift. MOH intensified the surveillance programme both in urban and rural areas in order to fulfill the expected increased demands for potable water with the rapid expansion of economic development in the country.

1.2: BAKAS unit, Ministry of Health

The objectives of environmental health program are to assess and control the physical, chemical and non-human biological forces of the environment, which may adversely affect the health and social well being of public. BAKAS (Water Supply and Environmental Sanitation) unit was first introduced in 1974 to control water and vector-borne diseases through supplying safe water supply and sanitation facilities for rural areas (Engineering division of Environmental Health Unit, 1999). The Environmental Health Engineering activities under Ministry of Health have 4 core programmes (MOH, 1998):

a. Water supply and environmental sanitation programme including BAKAS
b. National drinking water quality monitoring and surveillance programme including KMAM
c. Environmental health protection programme
d. Clinical waste management programme

One of the objectives of water supply and environmental sanitation programmes is to provide adequate safe water to the rural community. The programme incorporates simple technological principles that emphasized on simple design, construction and maintenance. The requirement for the system is to deliver sufficient quantities of water that meets the basic health and hygiene requirement at minimum cost. These systems produce untreated but wholesome water and therefore the rural people are advised to boil their drinking water. The types of systems installed throughout rural areas in Malaysia are:

1. Gravity Feed System (GFS)
2. Sanitary wells such as Over Head Tank (OHT), Direct Connection (DC)
3. Rainwater collection (not available in Kelantan)

The development of rural water supply in the water supply and environmental programme was planned according to the 5-year Malaysia development plan. The overall status of rural water supply coverage is about 91.36%, which represent 1,735,004 rural houses with Malaysia populations of 8,905,484 (MOH, 1998). Table 1 showed that there was a decrease in percentages of BAKAS project from 28.84% in 1998 to 13.72% in 2000. The percentages of houses with no safe water supply actually increased 9.82% from 1998 to 2000 and this is a worrying situation. Some measures must be taken to overcome this problem.

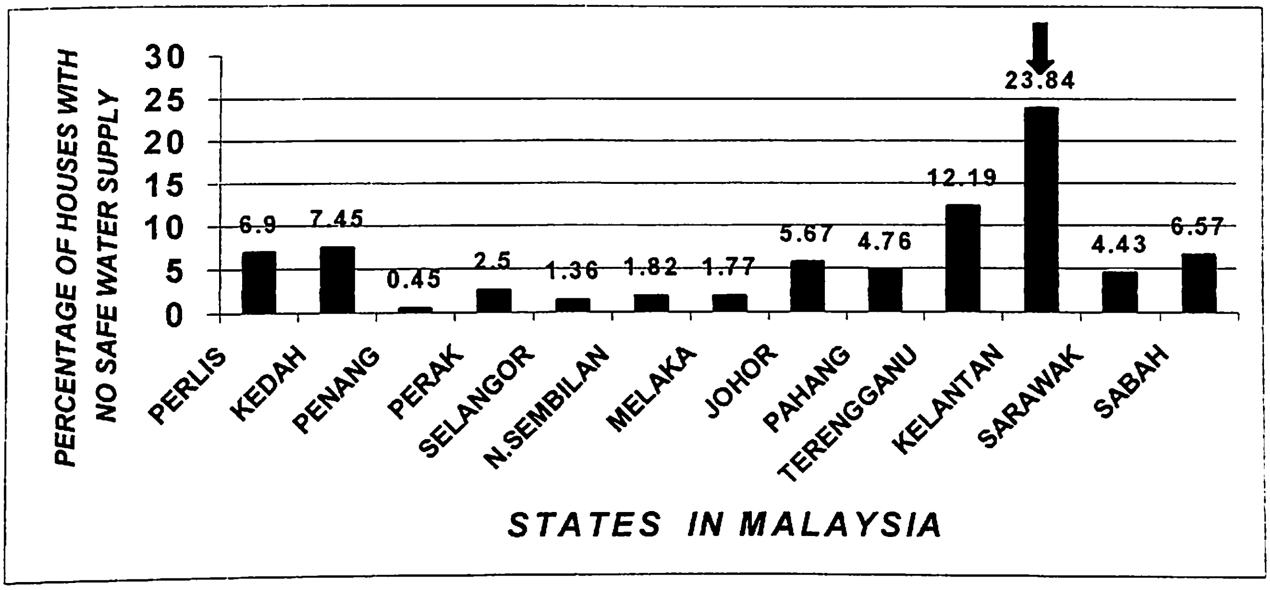
Table 1: Percentage of houses with rural water supply and percentage of houses with no water supply in Kelantan

TYPE OF WATER SUPPLY	1998	2000
MOH (BAKAS PROJECT)	**28.84**	**13.72**
AIR KELANTAN SDN BHD	34.22	40.53
OTHER AGENCIES	11.70	10.69
NO CLEAN WATER SUPPLY	25.24	35.06
TOTAL	**100.00**	**100.00**

Source: State Health Director Office, 1998 & 2000

Comparing with other states in Malaysia as shown in Figure 2, Kelantan also has the highest percentage (23.8%) of houses with no safe water supply.

Figure 2: Percentages of houses with no safe water supply by states in 1999.



Source: Annual report on BAKAS program, engineering unit, MOH 2000

1.2.1: Types of rural water supply that are concern in this study

Gravity Feed System (GFS)

This is one of the BAKAS rural water projects that serve public water supply, providing untreated water to the rural communities, using spring water from uninhabited catchments areas, which are relatively free from contamination (MOH, 1983). This system was constructed with a hillside concrete and stone silt box connected by, an underground pipe to a village tap. Water source is located at a higher level (e.g hill, mountain) than consumer house and uses gravity for the water to flow. This system can supply 300 to 500 houses depends on the capacity of the water to flow continuously, the size of the pipe and optimum pressure.

Tube well with overhead tank (OHT)

The selected tube wells for this study are of the drilled type because these types of tube well are nearly always potable when constructed and located to prevent pollution (Lehr *et al*, 1980). This system can supply up to 30 to 50 and sometimes a hundred houses depending on the depth of the well and water level. Electric pump, which is provided by the BAKAS unit, was used to pump up the water from the well to the overhead tank instead of using hand-pump or bucket with rope. The maximum depth can be as deep as 30 meters depending on the types of soil and water level. Refer to Appendix B.

Open dug well with no tank / direct connection to the house (DC)

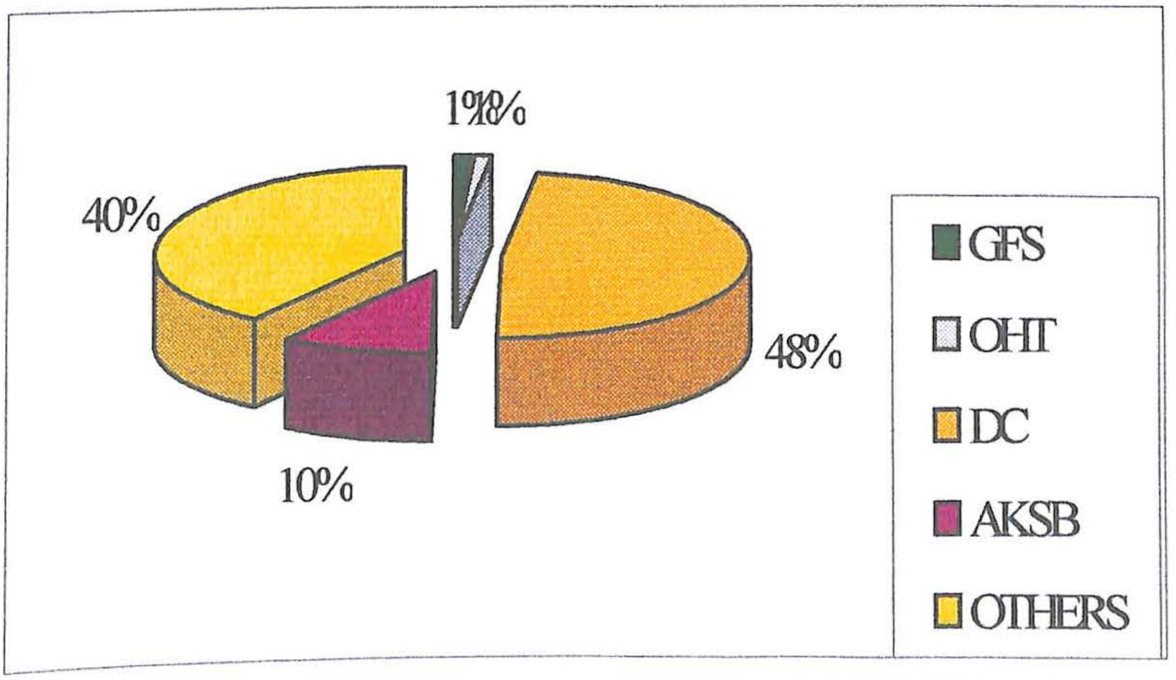
This is the cheapest type of well construction and can be done manually by villagers. This system can only supply 1 to 2 houses and use electric pump for it to function well. No tank is provided. Usually the well was up-graded from the old unsanitary well to sanitary well. The well depth can be as about 6 to 15 meters depending on the type of soil. The diameter of the well is usually 90 to 120 centimeters. Refer to Appendix B.

Air Kelantan Sdn Bhd (AKSB) water connection

AKSB water connection was purposely chosen for "other" types of rural water system. This system produced treated water with a conventional method involving process of aeration, flocculation, sedimentation, filtration and chlorination. BAKAS unit provided all the piping and water connection from the main pipe to the consumer house. The consumers just need to pay the water bills every month to AKSB. In Tanah Merah there's 5 water treatment plants whereby in Pasir Puteh, only 1 water treatment plant is available.

Figure 3 showed that in year 1999, DC is the most preferable rural water system (48%) in Kelantan because it is cheaper, easy construction and suitable for small water project. Others refer to estates, school and other privatized rural water system.

Figure 3: Percentage of rural water system by BAKAS project in Kelantan, 1999.



Source: Annual report on BAKAS program, engineering unit, MOH, 2000

1.3: Background of the study area

Kelantan has 10 administrative districts and only 6 districts have all 4 types of rural water systems by BAKAS unit, MOH. The districts are Gua Musang, Jeli, Machang, Kuala Krai,Tanah Merah and Pasir Puteh. Tanah Merah and Pasir Puteh were selected by using multistage random sampling method. Pasir Puteh located at the coastal area with a total number of 4611 (21.85%) houses for 103 189 population in rural areas used BAKAS water system in 1998. Pasir Puteh have a total number of 9 GFS projects, 184 of OHT projects and 133 of DC projects till year 1999. Tanah Merah is located in the inner part of Kelantan and BAKAS project supply up to 3675 (18.07%) houses for 93 181 population (MOH, 1998). Tanah Merah have a total number of 25 GFS projects, 38 OHT projects and 65 DC projects till year 1999. Refer to Appendix A.

1.4: Justification of study

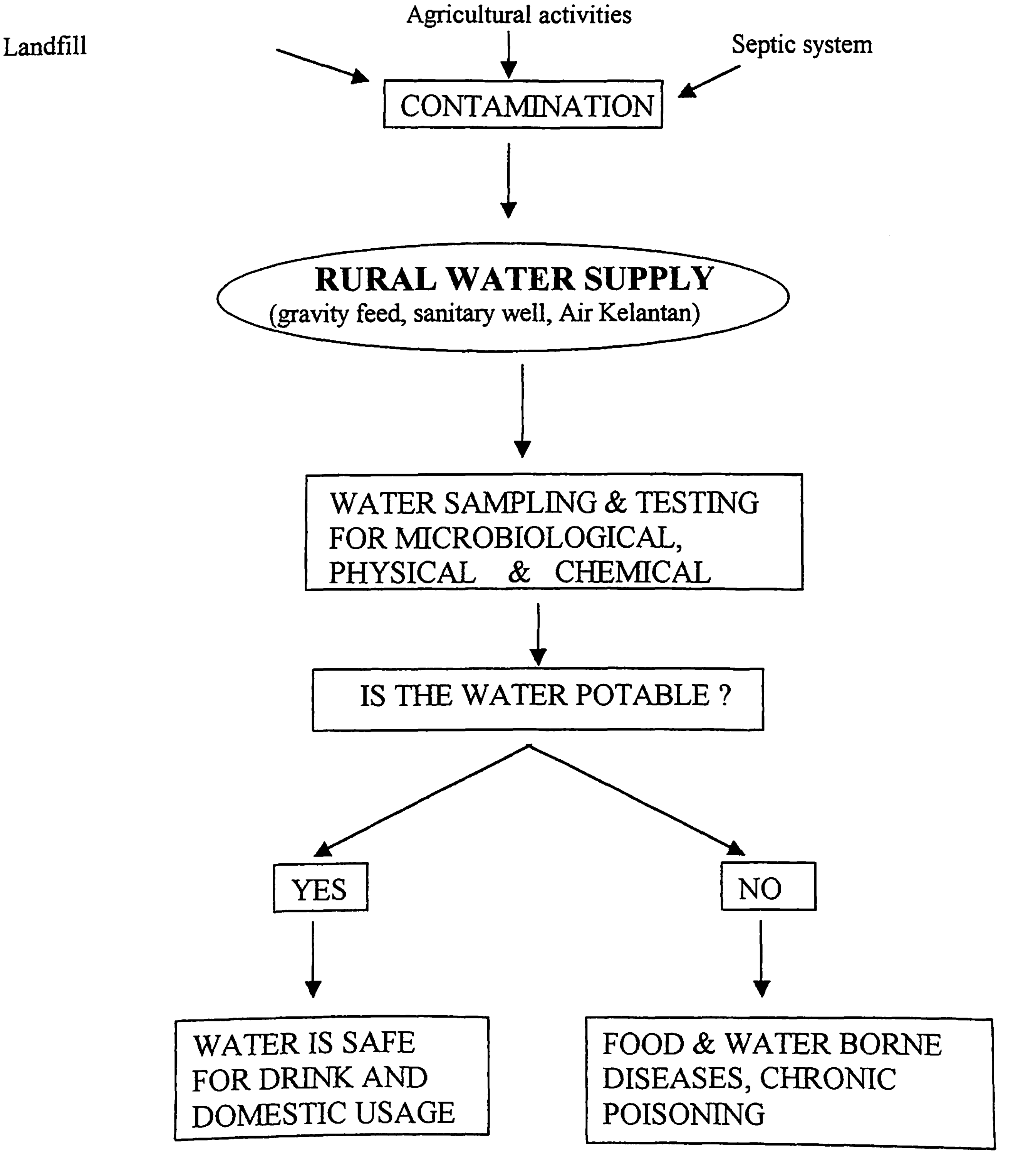
Surface water and underground water are the most important sources of drinking water in Kelantan. Groundwater is a very important source of water supply .It is relatively clean and less affected by weather. However, with rapid development and increasing number of chemical being released into the environment, the possible impact on bodies of water becomes a major concern. Drinking water monitoring is one of the interesting subjects in environmental health and water quality is an important issue for many years especially in Kelantan. At present, the monitoring and surveillance programme is limited to urban distribution system and some remote systems in plantation.

This is an exploratory study and neither similar study was done before nor there's any baseline data available. Thus, this study further extended to include all types of public water supplies in rural areas. Random sampling was carried out in individual houses and establishments to cover the water quality in storage tanks and household plumbing. This study was undertaken to assess the quality of drinking water in Kelantan in terms of its chemical, physical and microbiological characteristics. The study findings were to serve as a baseline data for efforts to improve rural water supplies and for comparison, when actions have to be considered subsequent to demographic shifts and water impoundment. It also aims to provide baseline information for future monitoring studies especially improving the quality and quantity of rural drinking water in Malaysia.

1.5: Conceptual framework

Refer to Figure 4.

Figure 4: Flow chart showed the conceptual framework of factors contributing to contamination and the potability of rural water system and the adverse effect of the unpotable drinking water.



1.6: Objectives

1.6.1: General

To study the potability of rural water supplies by BAKAS unit, Ministry of Health in Kelantan.

1.6.2: Specific

1. To assess the physical, chemical & microbiological parameters of drinking water from various rural water systems in Tanah Merah and Pasir Puteh districts.
2. To compare the potability of the 4 types of rural water systems.
3. To study consumers satisfactions on the quality and quantity of rural water supply.
4. To determine the level of risk for contamination for each type water system based on total sanitary survey score.

1.7: Research hypothesis

There is a difference in the potability of drinking water from the 4 types of rural water systems.

CHAPTER TWO

LITERATURE REVIEW

2.1: Water resources management

The most precious fluid on earth is not oil, but water. There are few challenges as important as conserving the world's usable water and supplying clean drinking water and water for irrigation to those who need it. Of all water on earth, 97.5% is salt water, and of the remaining 2.5% fresh water, some 70 % is frozen in the polar icecaps. The other 30% is mostly present as soil moisture or lies in underground aquifers. In the end, less than 1 % of the world's fresh water (or about 0.007% of all water on earth) is readily accessible for direct human uses. It is found in lakes, rivers, and reservoirs and in underground sources shallow enough to be tapped at affordable cost. Evaporation and precipitation make this water available on a sustainable basis (WHO, 2000).

The move to provide safe water to improve public health was started by John Snow back in 1845 in London, UK. International Conference on Primary Health Care in Alma Ata in 1978 had set targets that by the year 2000 all people would have access to safe drinking water and that pollution of water sources would no longer pose a threat to health (Anonymous, 1999). Water management is becoming increasingly comprehensive and complicated due to larger concentrations of population, commercial activities and industries around the cities and towns, increasing water consumption, increasing water pollution, increasing land use conflicts and climate changes (M. Azhar , 1999).

In Indian Government, 1999, norms for providing potable drinking water stipulate that 40 litres per capita per day (1 pcd) for humans may be provided for the purpose or drinking, cooking, bathing, washing utensils / house and ablution. Study by Robert *et al.*(1993) found that in water-scarce areas such as in Lima, Peru, sanitary education programs probably would not change hygiene practices. In these areas, an adequate supply of water is essential for good hygiene. Data presented by Briscoe (1984) also showed that, if poor women in developing countries were to choose the mix of activities to be included in Primary Health Care programs, improved water supplies would frequently constitute part of that mix.

2.2: Water potability

WHO defined water quality as the proportion of samples or supplies that comply with guidelines values for drinking-water quality and minimum criteria for treatment and source protection (WHO, 1997). All raw water for rural public water supplies should be treated where applicable or at least be disinfected (MOH, 1990). Water is defined to be potable when it is free from apparent colour, turbidity, odour, and objectionable taste, carcinogenic, mutagenic or neurotoxic substances (Akbar, 1989).

According to Drinking Water Quality Standard, drinking water must be clear, colourless and odourless. It must be pleasant to drink and free from all harmful organisms, chemical substances and radionucleides in which could constitute a hazard to the health of the consumer (MOH, 1983). The quality of drinking water is measured in terms of its physical, chemical, radiochemical and microbiological characteristics. Saskatchewan Research Council only measured bacteria and nitrate levels to determine water potability. According to Health Act on safe drinking water regulation, potable water means water that meets the standards established by microbiological standards and is safe as a drinking water without further treatment (MOH, 1990). BAKAS unit of MOH also measure the bacteriological parameter as the main indicator for satisfactory or unsatisfactory water sampling (MOH, 2000). So in this study, the presence of *Esherichia coli* is the main parameter to determine water potability. All raw water for rural public water supplies shall also be treated where applicable or at least be disinfected. Pima County (1998) stated that, in recognition that taste, odour, colour and other aesthetic qualities are important factors in the public's acceptance of and confidence in a public water system, water delivered shall at all times must be potable.

The "National Guidelines for Drinking Water Quality 1990" have been prepared by the Unit of Drinking Water Quality Surveillance, Ministry Of Health, Malaysia under the guidance of experts from WHO. Physical and chemical contamination emanating from natural geological sources, agricultural and industrial activities have to be monitored to ensure wholesome of drinking water and safety to consumers. The range of microbiological pathogen that can contaminate the drinking water is large, consisting of bacteria, viruses and intestinal parasites (WHO, 1996).

Changes in climate and rainfall will results in changes in the microbiological quality of water, both raw and in distribution. Alternative treatments for water may solve one particular problem but give rise to another (Watkins, 1993).

2.3: Water sampling and water testing

Water sampling involves transferring water from the original collection point to another location without causing any change in the properties. It is useless to make a highly accurate analysis of an improperly collected or handled sample. For meaningful water quality analyses, great care must be taken in the collection, transport and storage of water samples that such samples are representative of the water to be examined. Nowadays, water quality can be measured by arrays of equipment's with accuracy never been achieved before.

2.4: Water-related problems and disease.

The chemical constituents of natural water depend on geology, climate, topology and its biological contents. Agricultural, mining and industrial activity may influence the level of inorganic components in the water. The presence of elevated concentrations of undesirable elements may have adverse effects on human health and proper monitoring is needed to maintain good drinking water quality. The effect of drinking water, which exceeds the health advisory guidelines, wills depends on the type and degree of contamination, the amount of water consumed and the person's resistance to that contamination, which depends on age and other coexisting health problems (Margie, 1998).

Chemically, groundwater is intimately related to the environment through which it is flowing. In Kelantan, Perlis, Kedah and Kelang Valley, the pattern of changes of chemical character of groundwater are similar (Ismail *et al.*, 1993). Study by Shukur in 1997 showed that the main sources of pollution of Sg.Langat, Selangor were from industries (52%), sewage treatment plants (31%), animal husbandry including pig farming (4.0%) and construction sites (3.0%). The impacts of industrial developments on drinking water quality are due to recalcitrant organic and the deterioration of water quality of receiving streams (Rakmi *et al.*, 1990).

The concentrations of heavy metals in drinking water in Sabah are below the permissible levels set by Ministry of Health. Nevertheless, in view of the rapid development and growing population, the quality of drinking water should be monitored in order to protect the public from the ill effect of any future development related pollution (Dayang *et al.*,1990). Chemical contaminants are not normally associated with acute effects and thus are in a lower priority category than microbial contaminants, the effects of which can be immediate and massive. Consideration of chemical contamination of drinking water is almost irrelevant where water-borne infections and parasitic diseases are rampant in a society (Gorchev,1998).

Recent works in Rwanda, Thailand, Indonesia, Zambia and Nigeria by several researchers have shown high levels of fecal contamination of water used in the house. Very often safe and sanitary supplies have been developed by various agencies but when the water actually consumed is analyzed the levels of pollution detected are higher than the levels formed in unimproved supplies (WHO, 1997).

There are 3 crucial concerns in relationship between water and health (WHO, 1992):

1) The constraints faced by water-poor countries and their impact on human activities.
2) The maintenance of water quality in the face of growing demand.
3) The direct link between health and water, especially concerning diseases associated with insufficient and poor-quality water and with inadequate provision for the disposal of wastewater.

Temporal variation in drinking water turbidity, an increase in turbidity of 0.5 nephelometric turbidity unit (NTU) at one of the plants was associated with relative risk for gastrointestinal events of 2.35 among children (95% CI=1.34, 4.12) and 1.17 among adults (95% CI=0.91, 1.52) (Robert, 1996).

Communities with deteriorating water systems have more risk to spread illness unless water supplies are properly operated and maintained. Effective education to improve compliance of boiling water is needed (Frederick et al., 1997). But Environmental Protection Agency (1999) found that by boiling water contaminated with nitrate could increase the nitrate concentration and the potential risk since boiling water could reduce half of the water volume. Study by Win Kyi *et al.* (1990) in Tumpat, Kelantan proved that the practice of boiling water needs to be accompanied with other aspects of hygiene and type of water supply influenced significantly the presence of bacteria.

2.5: Water disinfections

According to the Health Act on safe drinking water regulation of Malaysia, disinfections is a treatment process that kills or inactivates organisms, which are infectious or injurious to human health or are indicative of the presence of organisms which are infectious or injurious to human health (MOH, 1990). Chlorination is the most widely used method for disinfecting water supplies. It is convenient to use, effective against most waterborne pathogen.

However, chlorination can result in formation of trihalomethanes (THM'S) and other halogenated hydrocarbons that are carcinogenic. Recently there has been interest in the relationship between byproducts of disinfections of public drinking water and certain adverse reproductive outcomes, including stillbirth, congenital malformations and low birth weight (Keegan, 2001). Study by Timothy (1997) also showed that exposure to chlorinating by products in drinking water is associated with increased risk of colon cancer.

Study by Meri (1994) showed that the carcinogenic and mutagenic compounds found in chlorinated drinking water have raised concern over the potential long-term health effects of water chorination and chlorinating by-products. However, the recent study by Jakkola *et al.*(2001) did not provide evidence that prenatal exposure to chlorination by products at the relatively low concentrations encountered in Norwegian drinking water increases the risk of the studied outcomes.

Chlorinating by products is 10 to 100 folds higher in surface than in ground waters has provided a basis for exposure estimates in many epidemiological studies (Kenneth, 1994). The choice of disinfecting requires weighing the disinfectant efficacy against the toxicity of the products produced. The production of chlorinating by-products depends on raw water quality and chlorinating practices.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1: Research design

This is a cross-sectional study, which was conducted from 16 August 2000 till 29 July 2001 in Tanah Merah and Pasir Puteh districts, Kelantan.

3.2: Sampling Method

3.2.1: Reference population

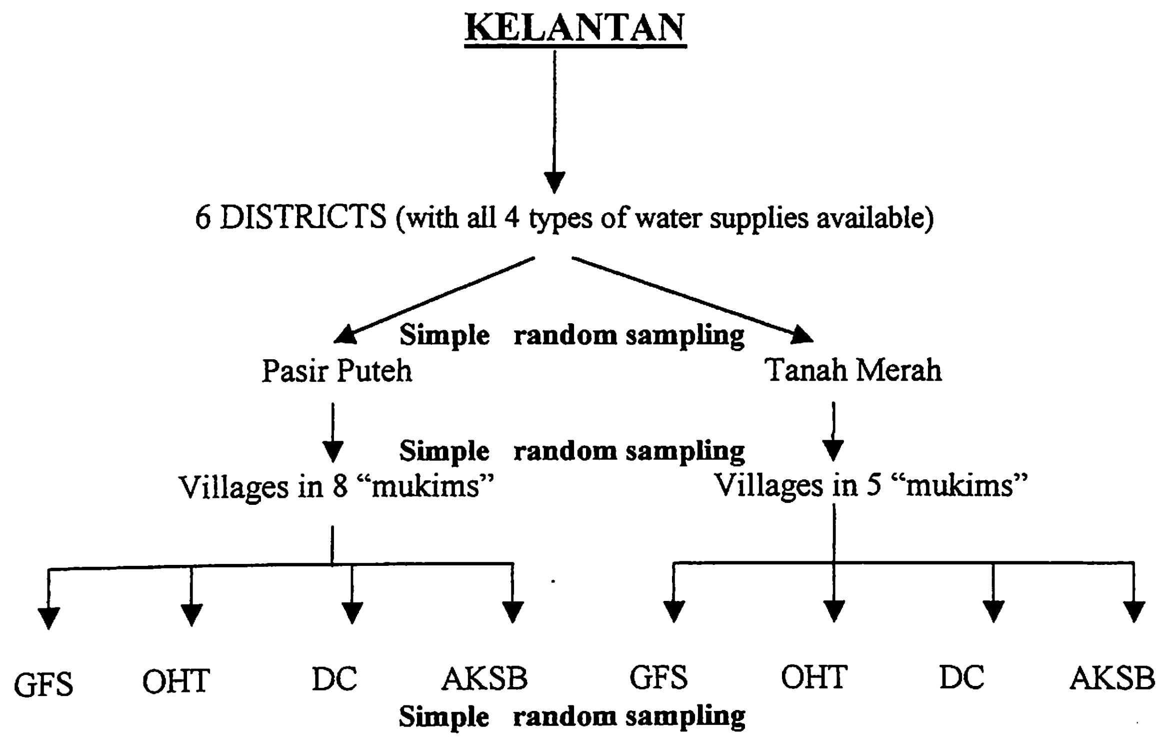
All houses in rural areas that received water from Kelantan BAKAS project.

3.2.2: Study population

Hous es received water supply from rural BAKAS projects in T.Merah and P.Puteh.

Figure 5 showed the diagram on how the houses were selected by multistage random sampling.

Figure 5: Flow chart showing sampling procedure (multistage random sampling)



3.3: Sample size calculation

Sample size was determined using the formula of two proportions (Dobson, 1984) based on confidence interval of 95%, power of 90%, percentage of the potable water samples from OHT water system was 51.85% and DC water system was 25.00% from Pasir Puteh, BAKAS, MOH project in 1999 with 100% response rate. No data available for GFS and AKSB, so samples size cannot be calculated for other proportion value (P_3 and P_4).

P_1 (Proportion of potable water samples from OHT water system) = 0.52

P_2 (Proportion of potable water samples from DC water system) = 0.25

Z_α (Confidence interval of 95%)= 1.96

Z_β (Power of the study 90%)= 1.28

By using two proportions formula,

$$n = \frac{P_1(1-P_1) + P_2(1-P_2)}{(P_1 - P_2)^2} (Z_\alpha + Z_\beta)^2$$

$$= \frac{0.52(1-0.52) + 0.25(1-0.25)}{(0.52-0.25)^2} (1.96 + 1.28)^2$$

= 63 water samples from each types of rural water system.

So the minimum total sample size needed was 252 (1 to 1 ratio).

3.4: Research Instruments

3.4.1: Questionnaire survey form.

Questionnaires were asked from selected houses regarding their satisfaction on water quality and quantity with a total of 15 questions (WHO, 1997). The satisfactions on the taste, colour, odour and others parameters were asked. The response can be YES=1 and NO=0. Taste and odour originate from natural and biological sources or processes, from contamination by chemicals, as a by-product of water treatment and may also develop during storage and distribution. These parameters may be indicative of some form of pollution or malfunction during water treatment or distribution. The taste and odour of drinking water should not be offensive to the consumer. However, there is an enormous variation in the level and quality of taste and odour that are regarded as acceptable. No health–based guideline value is proposed for these parameters (WHO, 1993). Refer to Table 2 and Table 3.

3.4.2: Water sampling and analysis

Water samples were taken from interviewed household and analyzed on field / Drinking Water Quality Control (KMAM) laboratory at the Health Office. 14 parameters were tested and compared the violation with permissible level from MOH (Refer to table 2). Most of the water samples were analyzed on field for the chemical, physical and microbiological parameters by using standard measures/ instruments provided by MOH. All instruments are checked and calibrated regularly (at least every 2 weeks) by the Public Health Inspector so as to get a valid result. Refer to Table 3.

a. Microbiological

Sample collections ~ Bacteriological samples were collected by using aseptic technique. 100 ml of pipe water was collected into sterilized whirl-pack thio bags and put into icebox during transportation to laboratory.

Water analyses~ The sampled water were filtered through a membrane filter with 0.45 micro liter pore size. The membrane then was transferred to an absorbent pad (petri dish) and soaked with a selected medium (Lauryl Sulfate Broth) and incubated at 44 ^{0}C for 16 to 18 hours to allowed the enumeration concentration of *E.coli* (Millipore, 1992). *E.coli*, the most discriminating marker for faecal contamination, is the microbiological indicator of choice for drinking water potability and safety, especially in developing countries with limited resources, where disinfection of water source is neither economically nor technically feasible (WHO, 1993). Study by Kravitz *et al.*(1999) also supports the WHO recommendation that *E.coli* should be the principal microbial potability indicator for untreated rural water supplies, which may contain nonspecific bacteria of unclear sanitary significance. Drinking water safety dictates that no *E.coli* should be present. Refer to Table 2 and Table 3.

b. Physical

For physical parameters such as pH, colour, turbidity free residual chlorine, temperature, conductivity and total dissolved solid need to be tested the field as soon as possible to get a valid result. Refer to Table 2 and Table 3.

c. Chemical

WHO (1993) selected some 120-priority chemicals for evaluation in the Guidelines for drinking water quality, and health-based levels of exposure were recommended for 95 of these. The selection of chemical for evaluation was guided by 3 main criteria:

1. Substance presented a potential hazard for human health;
2. Substance was known to be present frequently and at relatively high concentrations in drinking water;
3. Substance was international concern (WHO, 2000).

The chemicals tested were total hardness, total dissolved solid, ammonia, iron, sulphate, phosphate and nitrate. Only 7 chemical parameters were tested in this study due to:

a. more cheaper & affordable (limited budget ~ RM25.00 for each water samples)

b. easily done on field

c. selected parameters that always have violation in Kelantan

For chemicals such as test for ferum, sulphate, phosphate and nitrate were also done on field but for nitrogen ammonia and total hardness were done in KMAM laboratory at the specific health office because it involved hazardous chemicals and reagent. Refer to Table 2 and Table 3.

Table 2: List of parameters tested, the descriptions and the negative health effect of each parameter.

PARAMETERS	SOURCES/ DESCRIPTION	NEGATIVE HEALTH EFFECT
Microbiology		
1. E.coli	Human and warm blooded mammal's fecal waste.	Can cause diarrhea, cramps, nausea, headache and other symptoms. Indicator for fecal contamination.
Physical		
2. pH	Very important parameter to ensure satisfactory waters clarification and disinfection.	No direct impact. Extreme values of pH can result in the contamination of drinking water and in adverse effects on its taste, odour and appearance.
3. colour	Due to presence of coloured organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil (strongly influenced by iron and other metals).	No health effects but may be the first indication of a hazardous situation.
4. turbidity	Soil runoff	No health effects but can interfere with disinfection and provide a medium for microbial growth.
5. free residual chlorine	Chlorine is the main disinfecting agent.	Adverse effect with the chlorine by-products.
6. temperature	-	No health effect. Cool water is generally more palatable than warm water. High water temperature enhances the growth of microorganisms and may increase taste, odour, colour and corrosion problems.
7. conductivity	Related to TDS, depends on chemical composition and ionic charges on water ions.	-

Table 2: continued……….. **Chemical**		
8. total hardness	Calcium and magnesium dissolved in water are the two most common minerals that make water "hard"	Hard water is not a health risk, but nuisance because of mineral buildup on fixtures and poor soap / detergent performance. Deposits in pipes may reduce water flow.
9. total dissolved solid ~ comprise inorganic salts (eg; calcium, magnesium, potassium, bicarbonates, chlorides, sulfates) and small amounts of organic matter that are dissolved in water.	Originate from natural sources, sewage, urban run-off and industrial wastewater. Concentration of TDS depends on geological regions owing to differences in solubility of minerals.	No health effects. However, the presence of high levels of TDS in drinking water may be objectionable to consumers.
10. ammonia	Originates from metabolic, agricultural and industrial processes and from disinfection with chloramine.	Not of immediate health relevance but concentration of > 1.5 mg/l may cause odour problem and > 35 mg/l may cause taste problems. It may also compromise disinfection efficiency.
11. iron	Natural deposits, corroded metal distribution pipes	No health effects but can facilitates the growth of 'iron bacteria' and high level may effect taste and may cause staining.
12. sulphate	Natural deposits, steel and metal industries, fungicide manufacturing	Have a laxative effect (diarrhea) that can lead to dehydration especially in infants.
13. phosphorus	Natural deposits, in fertilizer are called superphosphate	Inflammation of mucous membrane, dermatitis, conjunctivitis
14. nitrate	Runoff from fertilizer use, leaching from septic tanks, sewage, erosion of natural deposits	Methemoglobulinemia or "Blue baby syndrome" in infants under 6 months

Source: Guidelines for drinking-water quality, WHO (1996)

Table 3: Permissible level by MOH, the instruments and the reagent used for each item.

TYPE OF ANALYSIS	PERMISSABLE LEVEL MOH	INSTRUMENTS USED	REAGENT/CHEMICAL USED
1. GROUP 1			
-BACTERIAL			
Faecal coliform (specific for E.coli)	0	MILLIPORE SET (Whirl-pack thio bags, pesterilized petri pad, Millipore filtration kit)	Membrane Filtered Culture Broth
-PHYSICAL			
pH	6.5-9.0	Portable Hach One pH Meter (Model 43800-00)	-
Colour	15 Hazen	Colour Comparator	-
Turbidity	5 NTU	Portable Turbidimeter (Model 2100P)	-
Free residual Chlorine	>0.2mg/l	Hach Model DR 2000 Spectrophotometer	DPD (diethyl-para-phenylene diamine) free chlorine
Temperature	^{o}C	Temperature meter	-
Total Hardness	100	(by manual)	Titraver EDTA solution, Manver 2 Hardness powder pillow, Buffer solution
Conductivity	100 mg/l	Conductivity /TDS Meter (Model 44600)	-
2. GROUP 2			
- CHEMICAL	(mg/l)		
Total dissolved solid	500	Conductivity /TDS Meter (Model 44600)	-
Ammonia (NH_3)	0.5	Hach Model DR 2000 Spectrophotometer	Deionized water, mineral stabilizer, polyvinyl alcohol, Nessler reagent
Iron (Fe)	0.3	Hach Model DR 2000 Spectrophotometer	Ferrous iron reagent powder pillow
3. GROUP 3			
- CHEMICAL			
Sulphate(SO_4)	400	Hach Model DR 2000 Spectrophotometer	Sulfaver 4 sulfate powder pillow
Phosphate	0.2	Hach Model DR 2000 Spectrophotometer	Phosvers 3 phosphate powder pillow
Nitrate	10	Hach Model DR 2000 Spectrophotometer	Nitrate 5 nitrate powder pillow

(National Guidelines for Drinking Water Quality, MOH, 1990)

3.4.3: Sanitary survey form

The forms were prepared by Engineering Services Division, MOH (1983) that includes specific checklist for each rural water system. Sanitary survey is an on-the-site inspection and evaluation of all conditions, devices and practices in the water supply system that poses or could pose a danger to the health and well being of the consumer. There is a need for both sanitary inspection and analysis to be complementary. There are many occasions when the source of contamination is not visible by sanitary inspection. Remote contamination of the aquifer (for groundwater), can only be detected by bacteriological or physical-chemical analysis.

The survey may be partial or complete depending on circumstances (MOH, 1983). Researcher filled the sanitary survey form, by observation and asking information from the committee members for every water system. The forms contains specific checklist for each rural water system in which potential hazards are listed and numbered. GFS had 15 items (KK/LB-1), OHT had 16 items (KK/LB-3) and DC had 17 items (KK/LB-2) that includes inspection from the water source until reached the consumer house. AKSB was not included because this system used different sanitary survey scoring method. Three levels scored the risks for contaminations, which is low, intermediate and high risk. The risk indicates potential danger to human health from a water source or supply. The total risk score were calculated as an outcome or dependent variable. Refer to Table 4.

For each type of water source, the proportion or percentage of points recorded as positive for risk during the sanitary inspection gives a sanitary risk score. This score can be arbitrarily associated with different levels of relative risk.

Table 4: Level of risk for contamination

Type of water supply	Total Sanitary Risk Score		
	Low Risk	Intermediate Risk	High Risk
GFS	0-3	4-7	8-15
OHT	0-3	4-7	8-16
DC	0-3	4-7	8-17

Source: Guidelines for drinking-water quality: Surveillance and Control of Community Supplies. WHO. 1997

3.5:Data analyses

Data were entered and analyzed by Statistical Package for Social Science (SPSS) Version 10.0. All the data were checked for the distribution normality by summarize the data, histogram with normal curve, box plot, p-p plot and Kolmogorov-Smirnov test. Univariate analyses were used to compare the potability of the 4 types of water supplies. For descriptive statistics, mean and standard deviation were calculated for normal distribution data. Median and interquartile range (IQR) were calculated for not normal distribution or skewed data. For inferential statistics, Chi-square, Fisher Exact, Independent t-test, One way ANOVA and Kruskal Wallis non-parametric test were used with a p value < 0.05 indicates statistical significance. Percentages of violation in the water samples were based on the drinking water standard from MOH. Refer to table 3.

Dependant variables are water potability with respects of physical, chemical and microbiological parameters, consumer satisfactions and sanitary survey score. Independent variables are type of water systems and household characteristics.

4.2: Limitations of the study

1. Intra-observer and inter-observer bias. Method/technique of water sampling and analyses may be different from each staffs. Sanitary survey was determined only by observation.
2. Instrumental bias- different district have different calibration of laboratory kit used. To overcome this problem, the same instruments were use for both districts but still consumed a lot of time and prolonged the period for data collection.
3. Some of the interviewed consumers were not at home during the sampling time, so need to come at another day.
4. Prolonged rainy season and flood from November 2000 till January 2001, thus data could not be collected during the time of period since because it would interfere the water analysis. Potability would be expected to deteriorate during rainy months since bacterial contamination of groundwater generally increases after heavy rains (Kravitz, 2000).

Figure 6: Gantt chart showing progress of the dissertation

1999 → **2000** → **2001** → **2002** →

AGENDA	S	O	N	D	J	F	M	A	M	J	J	O	S	O	N	D	J	F	M	A	M	J	J	O	S	O	N	D	J	F	M	A	M
Discussion & selection of topic.	✓																																
Proposal presentation and validation of questionnaire.		✓																															
Environmental health programme			✓	✓	✓	✓	✓																										
Preparation for Profesional Exam 2.								✓	✓																								
Discussion with MOH, Kelantan.										✓																							
Survey the study area and pilot study											✓																						
Data collection												✓	✓	✓	✓																		
Data entry												✓	✓	✓	✓																		
Data analysis																					✓	✓	✓	✓									
Paper presentation																									✓		M	G	✓				
Research write-up																														✓	✓	✓	✓

CHAPTER FOUR

RESULTS

The two districts involved in this study are Tanah Merah and Pasir Puteh. A total of 325 samples (161 samples from T. Merah and 164 from P. Puteh) were collected from 16.8.2000 till 29.7.2001. 80 (24.6%) samples were from OHT, 82 (25.2%) samples were from GFS, 84 (25.8%) samples were from DC and 79 (24.3%) samples were from AKSB.

Most of dependant outcomes were not normally distributed even within the groups. Kalmogorov-Smirnov Test showed that distribution of number of E.coli colonies, colour, turbidity, free residual chlorine, conductivity, total hardness, total dissolved solid, ammonia, iron, sulphate, phosphate and nitrate are not normally distributed with p value less than 0.05. This was due to significant of median differences of the parameters value for each water system at different sampling point. Thus, median with interquartile range and non-parametric test such as Kruskal Wallis test were used.

Table 5 showed the distributions of sampled houses from the two districts for each type of rural water system. Refer Appendix A for the maps of data distributions.

Table 5: Study areas in Tanah Merah and Pasir Puteh.

TYPE OF RURAL WATER SYSTEM	TANAH MERAH	TOTAL HOUSES	SAMPLED HOUSES	PASIR PUTEH	TOTAL HOUSES	SAMPLED HOUSES
1. OVER HEAD TANK (OHT) ~ TUBE WELL WITH A TANK	**BKT PANAU 1~**	44	33	**BUKIT ABAL~**	40	10
				BUKIT AWANG~	63	10
	BKT PANAU 2~			**PDG PAK AMAT~**	84	10
	a. BKT MERAH	7	7	**SEMARAK~**	37	10
	TOTAL	***51***	***40***	*TOTAL*	***223***	***40***
2. DIRECT CONNECTION/ NO TANK (DC) ~ OPEN WELL WITH NO TANK	**ULU KUSIAL 1~**	20	11	**JERAM**	84	12
	BKT PANAU 2~	22	19	**GONG KETEREH**	8	6
	JEDOK~	23	10	**CERANG RUKU**	31	25
	TOTAL	***65***	***41***	*TOTAL*	***123***	***43***
3. GRAVITY FEED SYSTEM (GFS)	**ULU KUSIAL 2~**			**BULIT ABAL~**		
	a. KUALA LAKAR	5	4	a. PERMATANG SUNGKAI	120	10
	b. TEGEWANG	29	14	b. KG. BENDANG	81	10
	c. CEGAR NERAK	32	11	**JERAM~ KG.TELOSAN**	215	11
	d. SOKOR BARU	39	12	**GONG DATUK~ KG.TAWEH**	66	10
	TOTAL	***105***	***41***	***TOTAL***	***482***	***41***
4. AKSB WATER CONNECTION	**JEDOK~**			**GAAL~**		
	a. FELDA KEMAHANG 2	311	39	a. GONG DATUK BARAT	83	10
				b. GONG DATUK TIMUR	55	10
				c. DALAM PISANG	24	10
	TOTAL	***311***	***39***	d. KEMUDU BONGKOK	60	10
				TOTAL	***222***	***40***
TOTAL		**532**	**161**		**1050**	**164**

4.1: Microbiological, physical and chemical parameters assessment and comparison of the potability of 4 types of rural water systems

Results on the microbiological, physical and chemical parameters for each rural water system are summarized in Table 6. GFS had the highest median for number of *E.coli* colonies (208± 662) detected and AKSB the lowest (0.00± 0.00). The median pH for OHT (5.55 ± 1.86) and DC (5.41 ± 0.93) is in acidic range (< 6.5) and normal median pH (6.5 – 9.0) for both GFS and AKSB. All system showed satisfactory results in median colour, which is less than 15 Hazen. Turbidity results showed low median turbidity in GFS (2.82 ± 4.31), OHT (1.83 ± 5.21) and AKSB (1.21 ± 1.30), whereas DC has higher median turbidity (3.50± 7.63). GFS give a median FRC of zero because no chlorination done in the system and no chlorine present naturally. Both OHT and DC have a low median of FRC, 0.00 ± 0.03 and 0.02 ± 0.08 respectively. Water temperatures for all water testing are all satisfactory. The median value for conductivity, total hardness and total dissolved solid are all far below the permissible level by MOH.

Chemical testing for ammonia, iron, sulphate, phosphate and nitrate also showed that the median values are far below permissible level. After analyses either with Non-parametric Kruskal Wallis Test or One-way ANOVA test, all parameters have significant mean or median differences between the four types of rural water systems except for phosphate (p value= 0.071).

Table 6: Descriptive statistics on the microbiological, physical and chemical parameters for each rural water systems

	Parameters	GFS N= 82	OHT N= 80	DC N= 84	AKSB N=79	**PERMISSABLE LEVEL MOH**	p- value
1.	**Microbiology** number of *E.coli* colonies	208 ± 662 [b]	0.00±57.50 [b]	38 ± 218 [b]	0.00 ± 0.00 [a]	0	**<0.0001***
2.	**Physical** pH	6.73 ± 0.22 [a]	5.55 ± 1.86 [a]	5.41 ± 0.93 [a]	8.20 ± 0.89 [a]	6.5-9.0	**< 0.0001#**
3.	colour	5.00 ± 0.00 [a]	5 ± 10 [b]	5.00 ± 0.00 [a]	0.00 ± 5.00 [b]	15 Hazen	**<0.0001***
4.	turbidity	2.82 ± 4.31 [b]	1.83 ±5.21 [b]	3.5 ± 7.63 [b]	1.21± 1.30 [b]	5 NTU	**<0.0001***
5.	free residual chlorine (FRC)	0.00 ± 0.04 [b]	0.00 ±0.03 [b]	0.02 ± 0.08 [b]	0.14 ± 0.72 [b]	>0.2mg/l	**<0.0001***
6.	temperature	26.95 ±2.30 [a]	28.8 ± 1.00 [a]	29.5 ± 3.7 [a]	30.10 ± 2.20 [a]	°C	**<0.0001#**
7.	conductivity	0.03 ± 0.01 [a]	0.04 ±0.06 [b]	0.06 ± 0.06 [b]	0.06 ± 0.02 [a]	100 mg/l	**<0.0001***
8.	total hardness	7.60 ± 5.95 [b]	9.50± 24.9 [b]	17.70 ± 19.80 [b]	15.80± 6.30 [a]	100 mg/l	**<0.0001***
9.	**Chemical** total dissolved solid (TDS)	0.01± 0.01 [b]	0.02 ±0.03 [b]	0.03 ± 0.04 [b]	0.03 ± 0.00 [a]	500 mg/l	**<0.0001***
10.	ammonia	0.00 ± 0.05 [b]	0.00 ±0.01 [b]	0.03 ± 0.29 [b]	0.00 ± 0.00 [a]	0.5 mg/l	**<0.0001***
11.	iron	0.01± 0.02 [b]	0.01 ±0.04 [b]	0.06 ± 0.13 [b]	0.00 ± 0.00 [a]	0.3 mg/l	**<0.0001***
12.	sulphate	0.55 ± 1.00 [b]	0.00 ±1.20 [b]	5.00 ± 7.00 [b]	9.00 ± 1.00 [a]	400 mg/l	**<0.0001***
13.	phosphate	0.10 ± 0.12 [b]	0.08 ±0.15 [b]	0.07 ± 0.12 [b]	0.08 ± 0.14 [b]	0.2 mg/l	0.071*
14.	nitrate	1.20 ± 0.40 [a]	1.40 ±1.33 [b]	2.20 ± 2.10 [b]	1.3 ± 0.53 [a]	10.0 mg/l	**<0.0001***

[a] mean ± standard deviation
[b] median ± interquartile range
One-way ANOVA test
*Non-parametric Kruskal Wallis Test

Table 7 summarized the results of the percentage of violation of the parameters tested after comparing with MOH drinking water standards. No violation in all water samples from 4 types of rural water systems for conductivity, total hardness, total dissolved solid, sulphate and nitrate. There are significant associations between types of rural water system and the presence of *E.coli*, pH, turbidity and free residual chlorine with p-value < 0.05. No significant associations found between types of rural water system and colour, ammonia, iron and phosphate with p-value > 0.05. The 4 variables that have significant association with types of rural water systems are presented further in next four figures.

Table 7: Percentage of violation of the parameters tested after comparing with MOH drinking water standards.

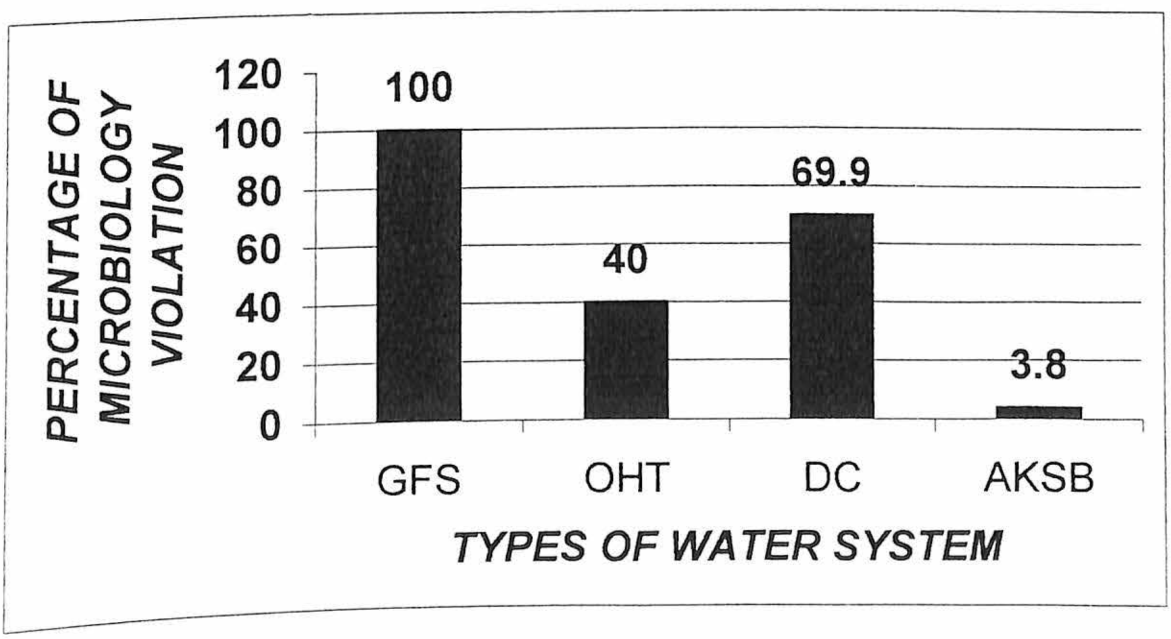
	parameters	GFS N = 82	OHT N= 80	DC N= 84	AKSB N= 79	Total violation	p-VALUE
1.	**presence of *E.Coli***	all samples violated	40	69.9	3.8	54.3	**<0.0001** ϕ
2.	**pH**	23.2 (low pH)	80 (low pH)	95.2 (low pH)	20.5(high pH)	55.2	**<0.0001** ϕ
3.	**Colour**	no violation	7.5	2.4	no violation	2.5	0.541 ϕ
4.	**Turbidity**	32.9	40.0	41.0	1.3	29.3	**<0.0001** ϕ
5.	**free residual chlorine**	all samples violated	all samples violated	89.2	56.4	86.7	**<0.0001** ϕ
6.	conductivity	no violation	no violation	no violation	no violation	no violation	-
7.	total hardness	no violation	no violation	no violation	no violation	no violation	-
8.	total dissolved solid	no violation	no violation	no violation	no violation	no violation	-
9.	**ammonia**	no violation	no violation	14.5	no violation	3.7	0.988 ϕ
10.	**Iron**	no violation	no violation	14.5	no violation	3.7	0.988 ϕ
11.	sulphate	no violation	no violation	no violation	no violation	no violation	-
12.	**phosphate**	15.9	18.8	15.7	16.7	16.7	0.945 ϕ
13.	nitrate	no violation	no violation	no violation	no violation	no violation	-

ϕ Chi square test

4.1.1: Microbiological

All (100%) GFS water samples were contaminated with *E. coli.* 70% of DC and 40% of OHT were violated. AKSB has a minimal water samples violated, which is only 3.8%. There was significant association (Pearson chi-square= 165.315, $p < 0.0001$) between water potabilty and types of rural water system. Other results showed a significant association between practice of chlorination and water potability with Pearson Chi-square=70.336, $p < 0.0001$ and Odd Ratio=0.127 (95% CI= 0.077,0.211).

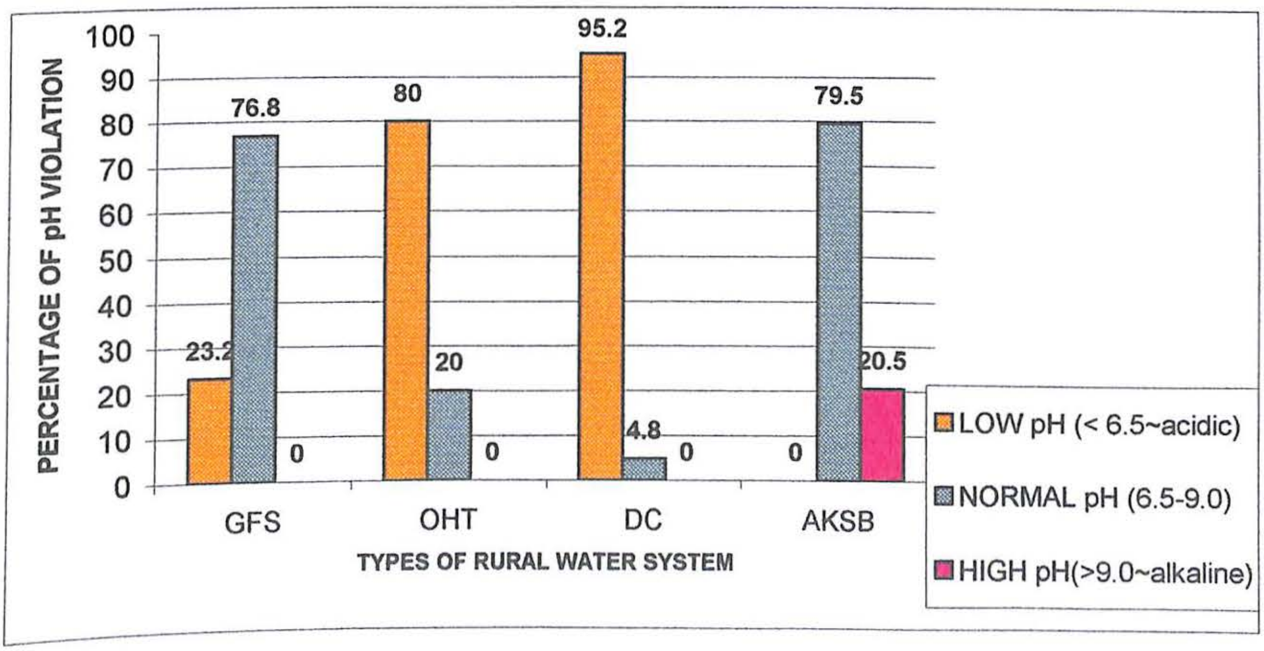
Figure 7: Percentage of microbiology violation (at least 1 *E.coli* colony presence) in 4 types of rural water systems.



4.1.2: Physical

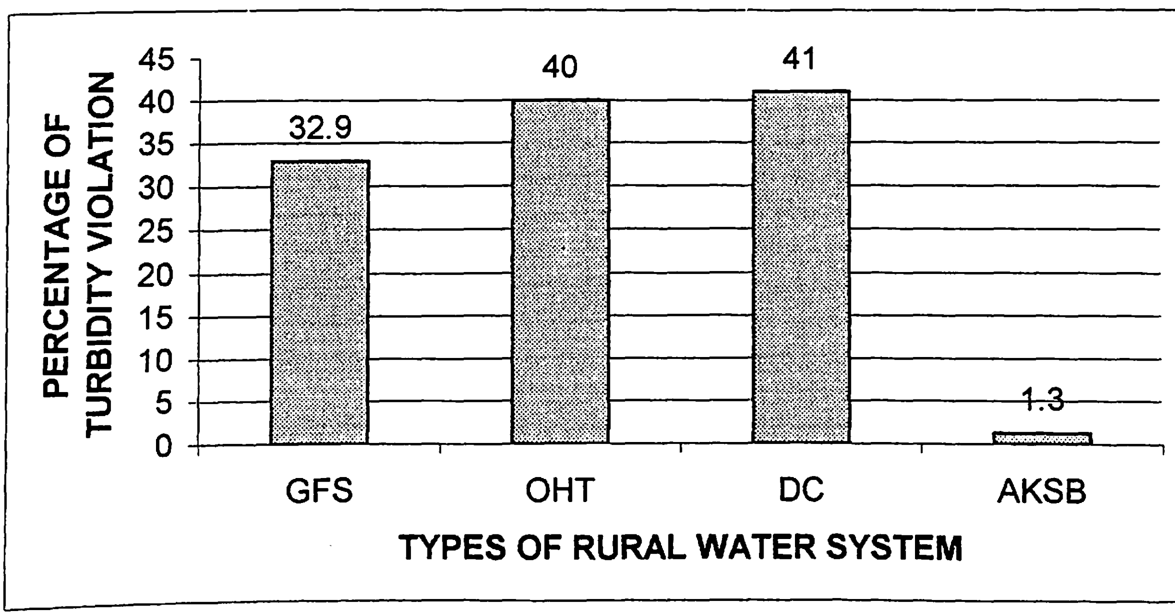
The pH parameter was grouped into low, normal or high pH. All the 3 types of rural water system (GFS, OHT and DC) have acidic type of water violation. DC has the highest violation (95.2%), followed by OHT (80%) and GFS (23.0%). Only 20 % of water samples from AKSB have violation in alkaline type. Majority of GFS and AKSB have normal pH.

Figure 8: Percentage of pH violation in 4 types of rural water system.



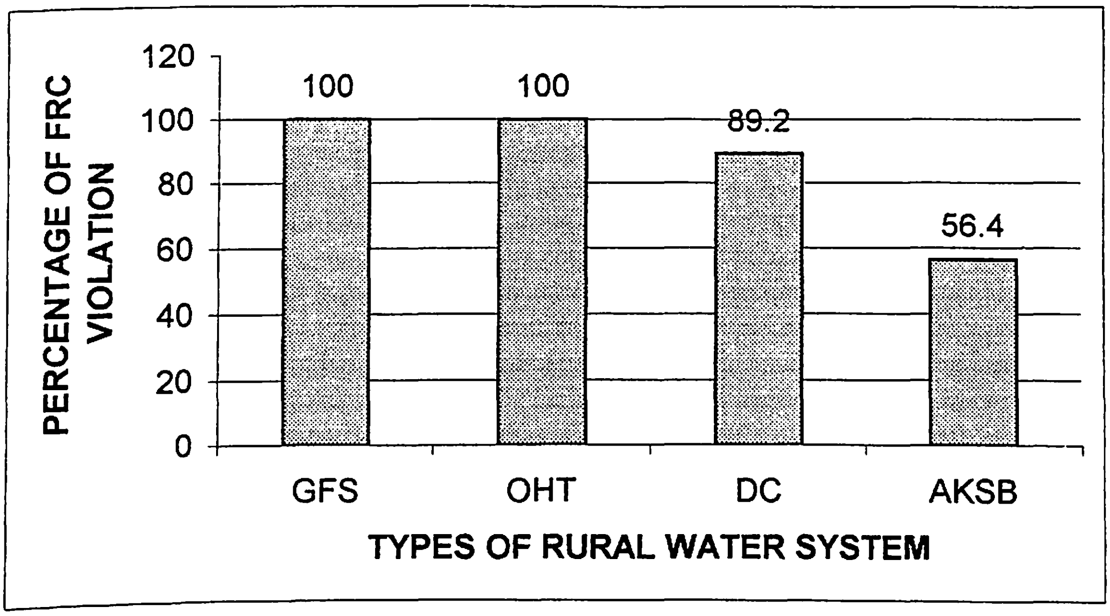
40% of water samples from OHT and DC having violation in turbidity followed by 33% from GFS. AKSB only have 1.3% violation.

Figure 9: Percentage of turbidity violation (> 5 NTU) in 4 types of rural water system.



All water samples collected from houses supplied by GFS and OHT water system have FRC violation. 89.2% of DC and 56.4% of AKSB have violation in FRC.

Figure 10: Percentage of free residual chlorine (< 0.2 mg/l) in 4 types of rural water system.



There is no violation in conductivity, total hardness and total dissolved solid in all 4 types of rural water system.

4.1.3: Chemical

There is no violation in sulphate and nitrate in all 4 types of rural water system. Only DC has violations (14.5%) both in ammonia and iron. OHT have the highest percentage (18.8%) of phosphate violation followed by AKSB (16.7%), GFS (15.9%) and DC (15.7%). No significant association found between all chemical parameters tested with types of rural water supply.

4.2: Consumer satisfactions on the quantity and quality of rural water supplies by BAKAS project.

Results in Table 8 showed there was significant differences (p value < 0.05) of mean number of water tap in the house and types of rural water system and no significant differences of mean (p value > 0.05) number of family members. Kruskal –Wallis test showed significance differences (p value < 0.05) of median duration (in years) using the water system, minimum and maximum pay per month between types of rural water system.

Table 8: Descriptive statistic on the characteristic of household of the study population (n=325) according to the rural water systems.

	Characteristic	GFS	OHT	DC	AKSB	TOTAL	p VALUE
1.	Number of family members	5.56 ± 2.39 [a]	5.13 ± 2.56 [a]	5.80 ± 2.86 [a]	6.13 ± 2.89 [a]	5.60 ± 2.64 [a]	0.255 [#]
2.	Number of water-tap	2.17 ± 0.65 [a]	2.94± 1.10 [a]	2.94 ± 1.41 [a]	5.15 ± 1.73 [a]	3.10 ± 1.47 [a]	**0.000** [#]
3.	Years of using	5.08 ± 1.53 [a]	5.90± 4.25 [b]	2.77 ± 3.22 [b]	15.2 ± 3.92 [b]	6.00 ± 8.00 [b]	**0.000** *
4.	Minimum pay for water supply per month	1.81 ± 0.40 [a]	5.85 ± 3.11 [b]	7.94 ± 8.30 [b]	7.14 ± 3.35 [a]	5.00 ± 7.00 [b]	**0.000** *
5.	Maximum pay for water supply per month	1.81 ± 0.40 [a]	8.48 ± 4.85 [b]	9.44 ± 9.95 [b]	9.00 ± 6.00 [b]	7.00 ± 12.00 [b]	**0.000** *

[a] Mean ± Standard Deviation

[b] Median ± Interquartile Range

[#] One- Way ANOVA

* Kruskal - Wallis Test

Table 9 showed that there were significant associations (p value < 0.05) between types of rural water system and the quantity, colour and odour of the rural water. No association between taste and types of rural water system. Only 13.9% of AKSB consumer satisfied with the water quantity although the water quality is satisfactory. Majority of the GFS, OHT and DC consumers are satisfied with the water quantity and quality. Further analyses by Independent T-test showed only years of using the water system had an association with the water quantity with $p < 0.0001$. For the colour satisfaction, test showed presence of significant association (p value <0.05) only between AKSB and OHT. For the odour satisfaction, test also showed presence of significant association (p value <0.05) only between AKSB and OHT.

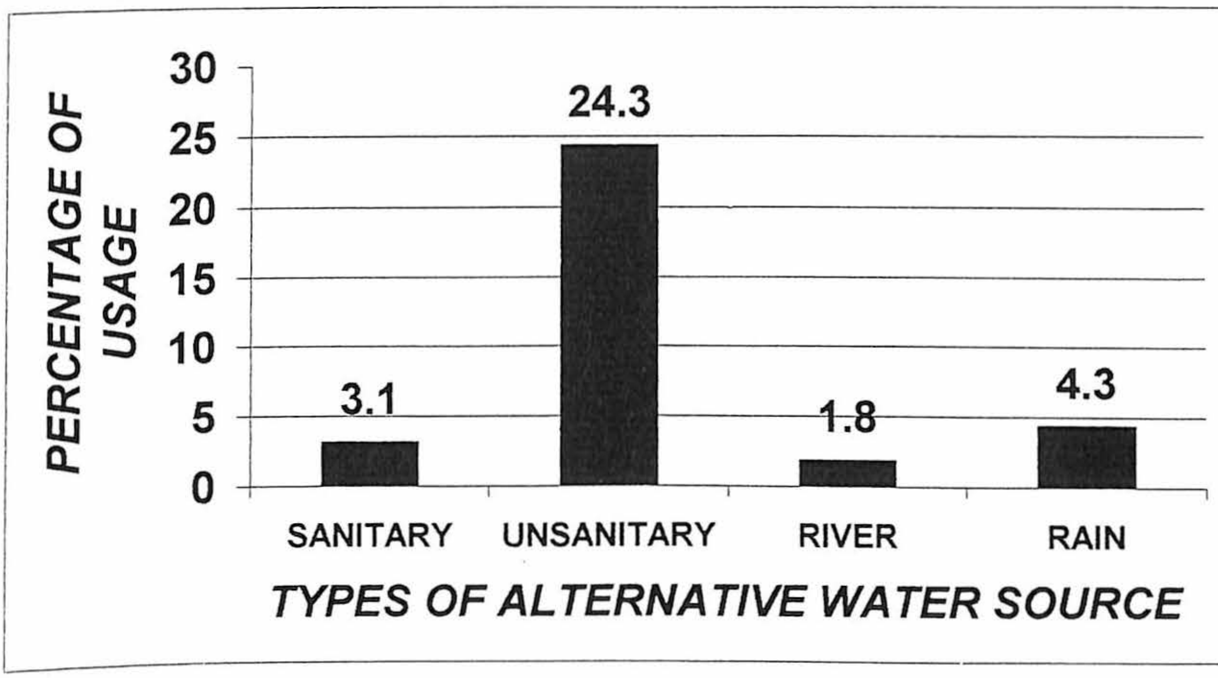
Table 9: Percentage of consumer satisfaction on the quantity and quality of rural water system

SATISFIED WITH WATER	GFS n = 82	OHT n = 80	DC n = 84	AKSB n = 79	TOTAL n = 325	p -VALUE
Quantity (YES)	65.9	86.3	96.4	13.9	66.2	**<0.0001**$^{\phi}$
Colour (YES)	85.4	66.3	86.9	92.4	82.8	**<0.0001** $^{\phi}$
Taste (YES)	82.9	85.0	94.0	93.7	88.9	0.052 $^{\phi}$
Odour (YES)	84.1	73.8	92.9	93.7	86.2	**0.001** $^{\phi}$
Others (YES)	95.1	91.3	94.0	97.5	94.5	0.421 $^{\phi}$

ϕ Chi-square Test

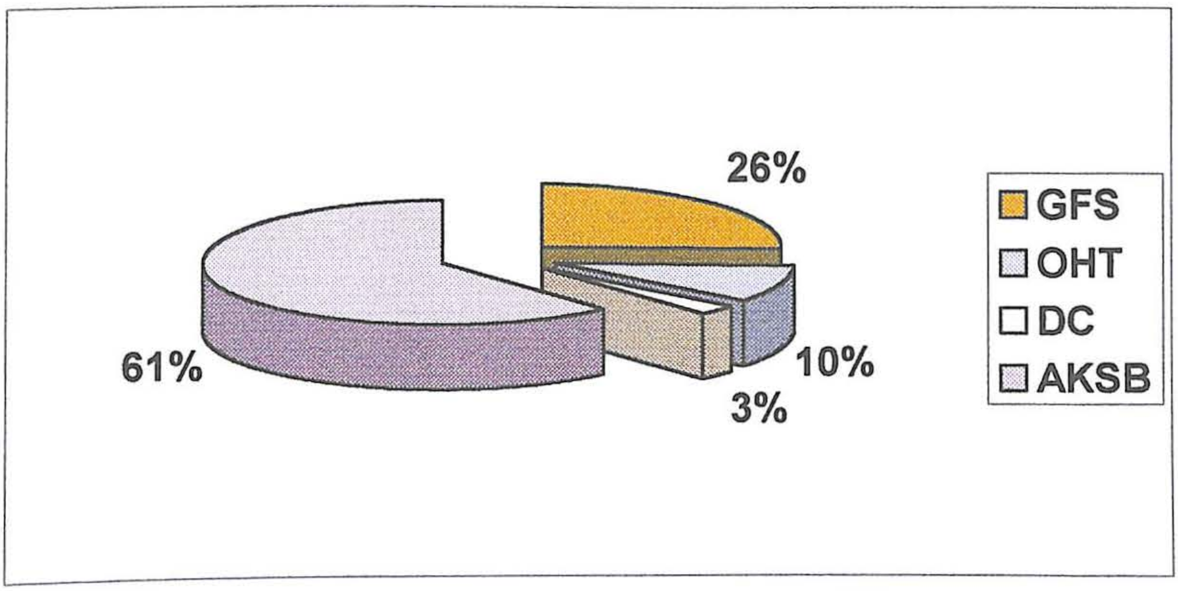
Types of alternative water source were divided into sanitary (all wells from MOH and treated water from AKSB), unsanitary (non-upgraded wells), river and rain. 24.3% out of 33.5% consumer with inadequate water supply used alternative water sources that were not monitored by MOH such as from unsanitary wells. The methods of rainwater collections also were are not proper and unsafe.

Figure 11: Percentage of usage of alternative water sources.



61% of household with complained of inadequate water supply receive their supply from AKSB water connection. DC is a good supplier of water because only 3% of the household complained of inadequate supply. There was significant association between the quantities of water with the types of water system (Chi-square= 144.344, $p < 0.0001$).

Figure 12: Percentage of houses with not enough water supplies

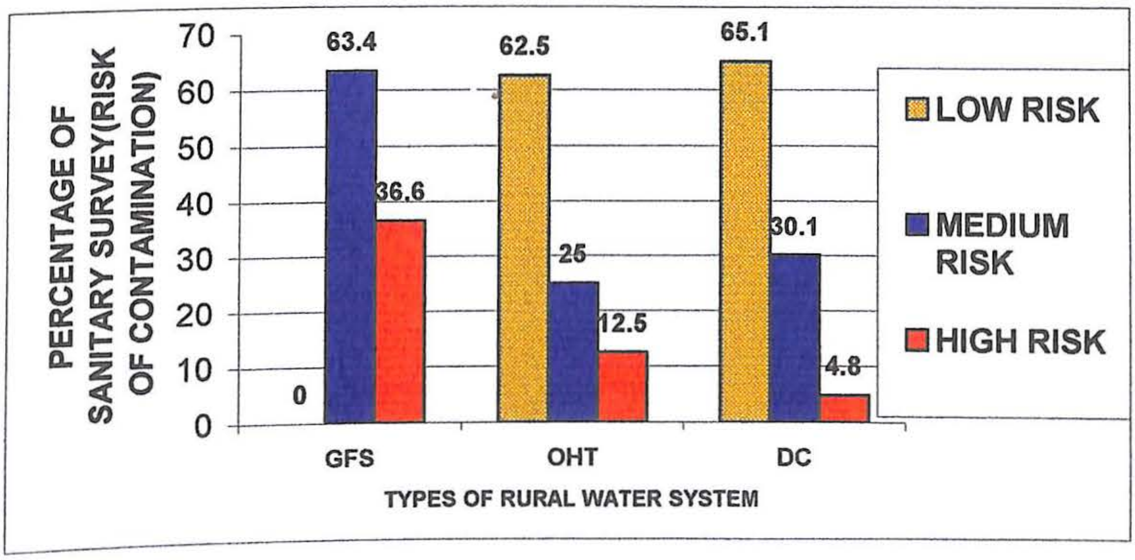


4.3: Results on the risk of contamination of rural water system.

Sanitary survey score were grouped by low risk, medium risk and high risk (WHO, 1997). This survey is more concerned with the high risk because it needs urgent action priority. GFS had the highest percentage of high risk (36.6%) of contamination compared with OHT (12.5%) and DC (4.8%).

There was an association between risk of contamination and presence of *E.coli* or water potability (Chi-square= 64.00, $p < 0.0001$). Chi-square test also showed that there was an association between risk for contamination and type of water system (Chi-square= 71.471, $p < 0.0001$).

Figure 13: Percentage of total sanitary survey for risk for contamination



CHAPTER FIVE

DISCUSSION

5.1: The potability of 4 types of rural water system in terms of microbiological, physical and chemical parameters

5.1.1: Microbiological

Half (54.3%) of total water samplings are contaminated with *E.coli.* GFS is an unsafe water supply in which all water samples collected were contaminated. This system has no opportunity for disinfections at any where between the water source, distribution and the consumer house. Any contamination can occur along the path. Although there's no reported case of water borne diseases in the study areas, precaution should be taken to prevent the adverse health effects upon continuous usage of the GFS water for domestic use. Study by Ismail (2001), showed that the outbreak of acute gastroenteritis in Kampung Sungai Genting,Perak on 6.7. 2000 was due to GFS water supply that is contaminated with *E.coli.*

There was some violation occurs in DC and OHT. Of course the safest water supply is the AKSB water connection because this is treated water but according to a study by Sinclair *et al.* (2000), they found that there have been a number of documented waterborne outbreaks in countries with a good water treatment practices.

Most potability problems in individual home water supplies result from the presence of microorganisms (bacteria, viruses, etc). Rarely do toxic minerals appear in these supplies. Most mineral present in groundwater are only nuisance and not dangerous to health (Lehr *et al*, 1980). This is one of the reasons why this study was more interested in bacteriology aspect of water potability. However, it is always advisable to have a water sample analyzed by a laboratory to determine the possible presence of substances in concentrations exceeding those recommended by MOH. The most unpotable rural water source is GFS, followed by DC and OHT. AKSB water connection is the most potable in term of microbiology parameters.

A detail study on GFS was done in Lesotho, South Africa (Kravitz, 2000), which found that 100% of the samples water is contaminated with coliform whether GFS is unimproved, semi-improved or improved water source.

When comparing with the dug well (DC) and tube well (OHT), the dug well have a higher microbiological violation (69.9%) than OHT (40%). Dug wells are more exposed for contaminations because of the depth were less than 30 meters (usually around 6 to 9 meters) depends on the type of soil. Majority of the dug wells that are included in this study are old well that reconstructed and upgraded by the BAKAS unit to be sanitary well. The age of the well also a contributing factors for the pollution. Study by Hayati (2000), in Kampung Pendang , Kedah showed that 66.7% of the water samples taken from 39 open dug well are contaminated with coliform. The study also found that there is a relationship between bacteria contamination and the depth of the well, distant from septic tank, apron conditions and the use of electric water pump. Study by Natrah *et al.*(2001), found that 12 out of 100 well-water samples collected from Kota Bharu, Bachok, Pasir Mas and Pasir Puteh, are contaminated with *Salmonella spp* and majority of the positive samples came from Kota Bharu.

5.1.2: Physical

For the physical results, all parameters are tested as recommended by WHO except for dissolved oxygen because this test only indicated for GFS. The total of pH violation is 55.2% in which majority of it has low pH especially in OHT and DC. One of the reasons was, these two systems are underground water and not treated water. So there is no alum or lime added in the water supply. These water system also more exposed to rain, which is more acidic type. Although water from AKSB is treated, still have problem with alkaline pH (20%). Process of adding alum and lime are done manually and the pH is not be monitored automatically.

Only 2.5% of the total samples have violation in colour with no violation at all in GFS and AKSB which indicates that the water are very clear and colourless. Turbidity is one the important parameter in physical appearances of the drinking water. In this study, only 29.3% of the total samples have turbidity > 5 NTU, in which the problem occurs in the GFS, OHT and DC. This is because of the great demand from the consumer, there's no enough time for natural sedimentation process to take place. But the median values of turbidity in all 4 rural water systems are below the permissible level. Consumption of turbid water may give serious health risk because the suspended particles can adsorb many toxic chemicals and heavy metals. Further more, disinfectant unable to kill target organisms because of a physical barrier or chemical reactions with the particles themselves. Clear water is potentially much safer to drink than turbid water and allows chlorination or disinfections to be effective. Study by Schwartz *et al.* (1998) showed that there was an association between hospital admission for gastroenteritis illness in elderly and drinking water turbidity.

Another interesting finding is the results of free residual chlorine with total violation of 86.7%. All samples from GFS and OHT have violation in FRC. There's no chlorination process for GFS. According to MOH, OHT should have regular chlorination, but in this study showed that the chlorination process is insufficient. The reason underlying this problem is due to no regular chlorination been implemented in both districts. The health staff only does the chlorination procedure at least twice per year or when there is a water-borne disease outbreak or every time after flooding. Because they believe that OHT should not have any contamination because of the depth of the well is usually very deep compare with DC. Another contributing factor is that the insufficient dosage of chlorination.

89.2% of DC has violation of FRC although the health staff often monitors this system. For DC, need to be chlorinated at least once a month but this procedure failed because of few reasons such as,

a. the consumers refused chlorination because they believe that it can kill their plantations and animals including fish
b. the consumer disliked the smell and taste of chlorine
c. the consumer believed that chlorine can damaged the electric pump
d. sometimes the health staff asked the consumer to put the chlorine by themselves but actually they used it for other purposes such as cleaning the drain and toilet.

Surprisingly for the treated water, they still have violation of FRC of 56.4%. The reason behind, not enough chlorine contact time because of great demand from consumer especially in both districts where the water supply from AKSB is always not enough. Study by Khairul *et al* (2000) for FRC in treated water in Hulu Langat, Selangor also found a low FRC (<0.2 mg/l) in 10% of collected water samples. If FRC is found in a sample it may be assumed that provided sufficient contact time between chlorine and the water has been allowed, the water will be bacteriologically safe at the point and the time the sample is taken. This is no guarantee that contamination has not occurred elsewhere in the distribution system.

All the water samples from the 4 types of rural water system do not have problem in conductivity, total hardness (especially magnesium) and total dissolved solid. In the 1950s, '60s, and '70s, epidemiologists were intrigued when some but not all ecologic studies suggested that "hard" (alkaline) water might have a protective effect against IHD. Many of the water sampled may have been high in magnesium.

5.1.3: Chemical

For chemical results, comparing with WHO water standard, this study only manage to test 5 chemicals out of 22 chemicals because of budget problem and lack on knowledge to handle other chemicals test. No violation of sulphate and nitrate in all 325 water samples. Only small percentage (3.7%) of violations occurs in ammonia and iron and that only in DC. DC is more exposed to underground contamination from soil, fertilizer and other substances compare with OHT because it is shallower. Unsanitary open wells are more expose for contamination from outside to go inside the well. Only small percentages of phosphate violation occur in all 4 water systems and the contamination can be due to superphosphate fertilizers.

Because of financial restraint, this study unable to assess the presence of other chemicals (such as aluminium), heavy metals (such as lead, mercury, arsenic), total biocides, organochlorine pesticides (such as aldrin, DDT, lindane), herbicides (such as 2,4-D) and radioactivity (such as gross α and gross β). Heavy metals in the environment have become a major concern in public health. Study by Shamsul *et al* (2000) found that heavy metal concentration (lead, cadmium and arsenic) in underground water supply among the residents in Kuala Lumpur and Seremban is safe for human consumption and domestic use and does not require any specific treatment.

5.2: Consumer satisfactions on the quantity and quality of rural water supplies by BAKAS project.

33.8% of the consumer still complained of getting inadequate water supply for daily used especially those who received water from AKSB (61.0 %). They have to get alternative water source to support their needs. These situations may expose them to water-borne diseases because majority of the sources they choose are unsanitary sources (30.4 %), which are not monitored by MOH. Besides that, 99.1% had no experience of any water related health problems or diseases and 99.7% agreed for continuing the BAKAS rural water projects because the quantity is more important for them than the water quality or potability. The water supply was also cheap that they can afford it.

Majority of the consumer (more than 80.0%) satisfied with the colour, taste, odour and other quality parameter of the rural water supplies although majority of the water actually are not potable after tested with the standard instruments. The consumers should be educated that although the water is colourless, odourless or tasteless by their judgments, the water safety is still doubtful.

5.3: Sanitary survey for determination the risk of contamination of rural water system

A single water sample is only representative of the moment in time when that sample is taken and changes in the environment, particularly rainfall, may quickly alter the level of contamination of a poorly protected source. Thus the sanitary inspection should at the very least reveal the most obvious points of contamination risk and can provide a robust and conservatively safe method of risk identification. Generally, these inspections could reveal more of the chronic risk of contamination than could be revealed by a single and costly bacteriological examination. Sanitary survey is rather economical and intelligent approach to bacteriological testing where funding is limited.

When comparing the 3 types of rural water system (GFS, OHT, DC) by sanitary survey, GFS have more high risk (36.6%) for contamination and difficult for disinfections because this system have big operational area and produce plenty of water. How do GFS can be contaminated?

a. Catchments area more than 5 hectors are more exposed to pollution or contamination from the risk of landslide or mudflow cause by deforestation
b. By any crop production, animals farms, human habitation or industrial activities upstream
c. Unfenced or not proper fenced of the dam cannot prevent animal from entering the dam area and contaminate the water source
d. No facility for removing the sand or any blocking materials
e. The exposed distribution pipe can lead to leaking of water and promote pollution from outside entering the distribution system especially if the pipe run across latrine or animal farm

Comparing with the tube well and open dug well, tube well have more high risk (12.6%). This result is not consistent with results on microbiological, physical and chemical violation. After assessment by risk analysis, actually OHT need low action priority and DC need higher action priority. There is a need for both sanitary inspection and water analysis to be complementary followed by risk assessment. These sanitary score forms enables a hazard score to be assigned to the particular water supply based on the total number of hazard found; however, differential weighting may be necessary to allow for local conditions. How do wells can be contaminated?

a. Problems with well casings, such as casings that are rusted, unsealed casings or casings that do not ground by at least 30 cm.
b. Close proximity of well to a septic tank or field, a barn or feed lot
c. Environmental condition such as flooding or heavy rains
d. Possibility of surface contamination because of shallowness of the well or water permeable overlying

Choosing which rural water system are appropriate for certain villages, staffs from BAKAS unit have to study thoroughly the area in terms of water source accessibility, number of population to serve, types of soil, geology of the area and other sanitation facilities including toilet and waste management. For building a new well, they have to follow the criteria in the well log. With a certain budget located for them in certain areas, they have to intelligently choose the right and suitable water system to be built. They followed certain guidelines given by MOH on how to build a new water system so as to prevent any contamination at a later stage.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1: CONCLUSION

Each types of rural water system have their own problems with the construction facilities, the maintenance, the consumer's perception, the quality and the quantity. The main problem for GFS, OHT and DC are the presence of *E. coli*, water p H less than 6.5, turbidity more than 5 NTU and low free residual chlorine with small percentage of violation in phosphate, iron and ammonia. AKSB water connection should have no problem with the water potability but this study showed that there were still some violations in E.coli, water pH more than 9.0 and low free residual chlorine.

The most important water quality parameter is the freedom from pathogenic microorganisms contained in faecal material. Results showed that the most unpotable rural water system is GFS in which all the samples taken are contaminated with *E.coli.* Comparing with 2 types of well system, OHT are better than DC. The most potable water system is AKSB water connection in which only 3.8% are contaminated. Thus the potability of rural water supplies in Tanah Merah and Pasir Puteh are still not very satisfactory. Although microbiological parameter (especially *E.coli*) is the principal potability indicator, the physical and chemical parameters should also be examined since some of these parameters can affect the presence of the bacteria.

Majority of the consumers is satisfied with the quality of rural water system although 66.2 % are still complaining of not enough water supplies. This is one of the worrying situations because they may use alternative water sources that usually are not safe and not monitored by the MOH.

Non–involvement of communities is still rated as a problem in almost all countries although it is not regarded as serious. Results showed poor practice of chlorination in which only 39.7% agree for disinfections.

Regular sanitary inspections and water analyses are both important in maintaining safe drinking water supplies. In this study, sanitary survey score showed that GFS is more at risk of contamination. OHT is more potable but less sanitary than DC. But after risk assessment with number of *E.coli* count and total sanitary score, actually OHT is better than DC. There are significant associations between sanitary survey score with the water potability and types of rural water supplies.

6.2: RECOMMENDATIONS

This is an exploratory study and can be extended for detail risk analysis and risk management. Further studies are needed on each water system in detail and to correlate with incidence of diseases such as water-borne diseases, cancer and poisoning. Knowledge attitude practice (KAP) study also can be done on safe drinking water and good personal hygiene. USM, Kelantan should have public/environmental health laboratory to monitor the drinking water quality especially during outbreak because currently the water samples have to be send to Chemistry Department in Kuala Terengganu or Petaling Jaya.

Drinking water protection is a shared responsibility, involving water suppliers, local and state governments, and business individuals. The general components of a source water protection program include delineation, contaminant source inventory, source water protection area management and contingency planning. Health staffs are now more aware of the importance of involving communities in all aspects of water supply and sanitation schemes including planning, design, construction and operation and maintenance. Any lack of involvement is mostly caused by insufficient health education and lack of village funds than lack of efforts on the part of the water authorities. Plans of action for improving access and quality of drinking water are:

a. water policies, legislation and standards
b. water quality surveillance and control
c. increase in access to safe water and promotion of disinfections

d. community participation and education

e. establishment of a partnership

f. prevent contamination from entering water source including proper management of waste water pesticides residual

i. consumer must know the source of their drinking water and get involved in activity to protect it

Good hygiene practices are an effective means of interrupting fecal-oral transmission and decreasing the interfamilial spread of diarrhea disease pathogens. Poor hygiene practices may be due to ignorance of sanitary principles, high cost, scarcity of clean water or distance from it. When the water is plentiful, adequate and convenient, programs that emphasize hygiene education increase personal sanitation practices and results in decreased rates of diarrhea. Consumer should be educated that although the water is colourless,, odourless or tasteless, the water safety is still doubtful.

Each rural water system needs individual method to overcome the problem of not potable water. For GFS, *E.coli* contamination can be prevented or minimized by proper fencing of the dam area to prevent human or animal from polluting the water source. Replacement of concrete dam by a high-density polyethylene tank with capacity of 400 gallons is suitable for small communities and easy maintenance. The raw water can also be treated by chlorine by connecting the water into a tank before reaching a few consumers. The water in the tank should be monitored regularly for the free residual chlorine level because excessive chlorination can give rise to gastrointestinal problems.

OHT actually provides a satisfactory water quality even with a minimal water treatment. But the quality can still be improved by:

i) Periodically inspect exposed parts of the well for problems such as cracked, corroded or damaged well casing, broken or missing well cap, settling and cracking of surface seals.

ii) Slope the area around the well to drain surface runoff away from the well.

iii) Install a well cap or sanitary seal to prevent unauthorized use of, or entry into the well.

iv) Disinfect drinking water wells at least once per year with bleach or hypochlorite granules, according to the manufacture directions.

v) Have the well tested once a year for coliform bacteria, nitrates and other constituents of concern.

vi) Keep accurate records of any well maintenance, such as disinfections or sediment removal that may require the use of chemicals in the well

vii) Avoid mixing or using pesticides, fertilizers, herbicides, degreasers, fuels and other pollutants near the well.

viii) Do not dispose of wastes in dry wells or in abandoned wells

ix) Never dispose of hazardous materials in septic system.

AKSB should supply their water for the houses with the unsatisfactory DC. MOH may stop upgrading the old unsanitary open well because the water quality is difficult to improved and easily got contaminated.

The unsatisfactory findings of the potability and safety of most domestic water supplies by BAKAS unit in T.Merah and P.Puteh was therefore suspected. This study recommend that in most cases, adequate protection of water sources could improve the hygienic of rural water supplies by effectively preventing *E.coli* from entering water systems prior to their delivery points.

One complex but necessary approach must be done to change people's habits that contribute to the pollution of drinking water. Strategies to promote proper household storage must be encouraged because stored water, touched by hands and unclean vessels, can become significantly more contaminated than the source. This approach could also promote home disinfections and the use of suitable water storage containers.

Combined environmental interventions (including water quality improvement and household sanitation) and community sanitation, which are likely to require significant institutional and economic investments, can have a powerful impact on reducing serious diarrhea disease in infants who are at greatest risk. Despite evidence that increased water quantity for personal and domestic hygiene is likely to be as important was water quality, clear cut solutions to improve health, based on water quality, water quantity and hygienic behaviour, remain elusive because of the complicated nature of water-related disease transmission. Strategies investigating the complicated relationship between human behaviour and health are being tested and pose a challenge.

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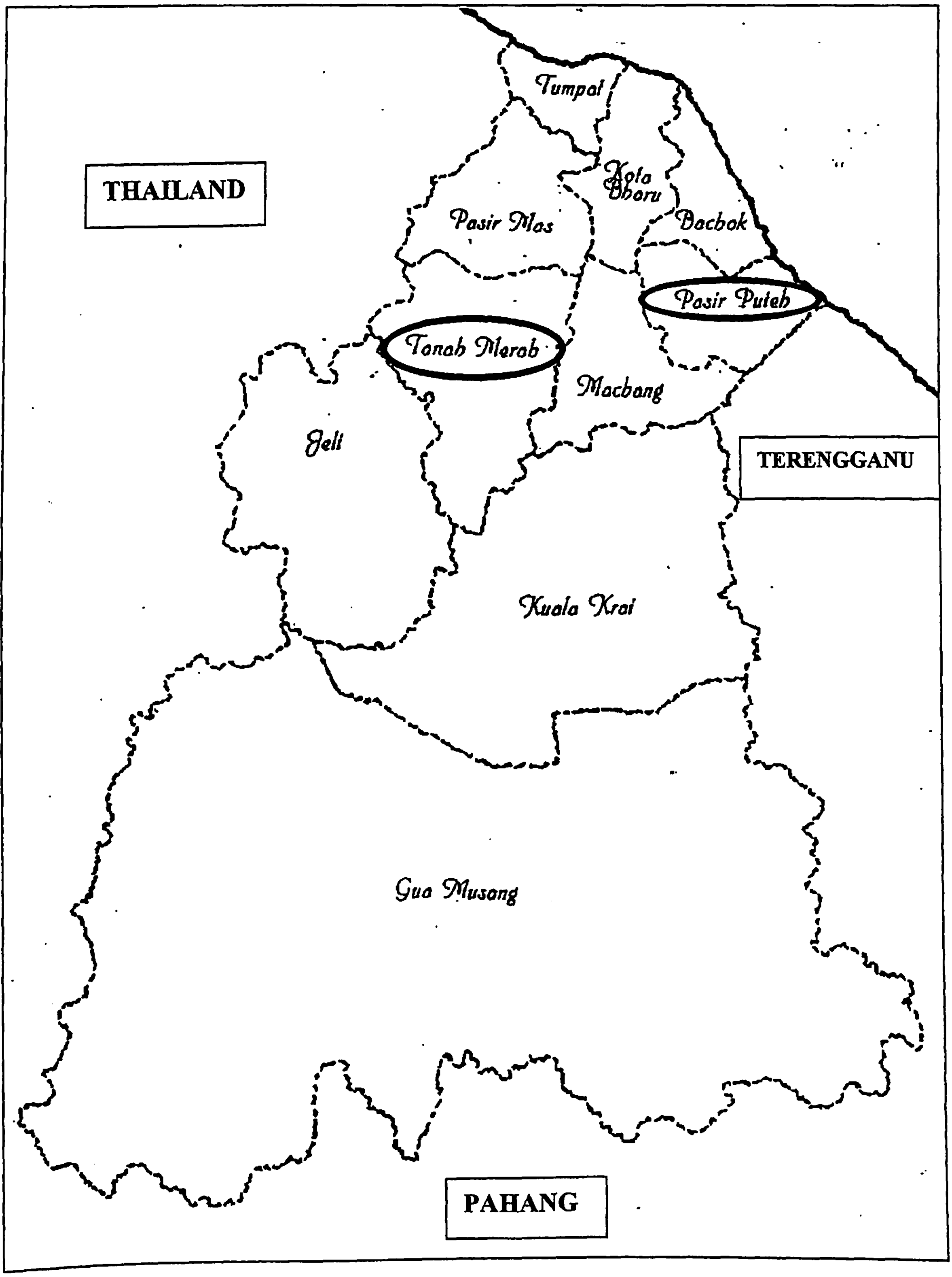
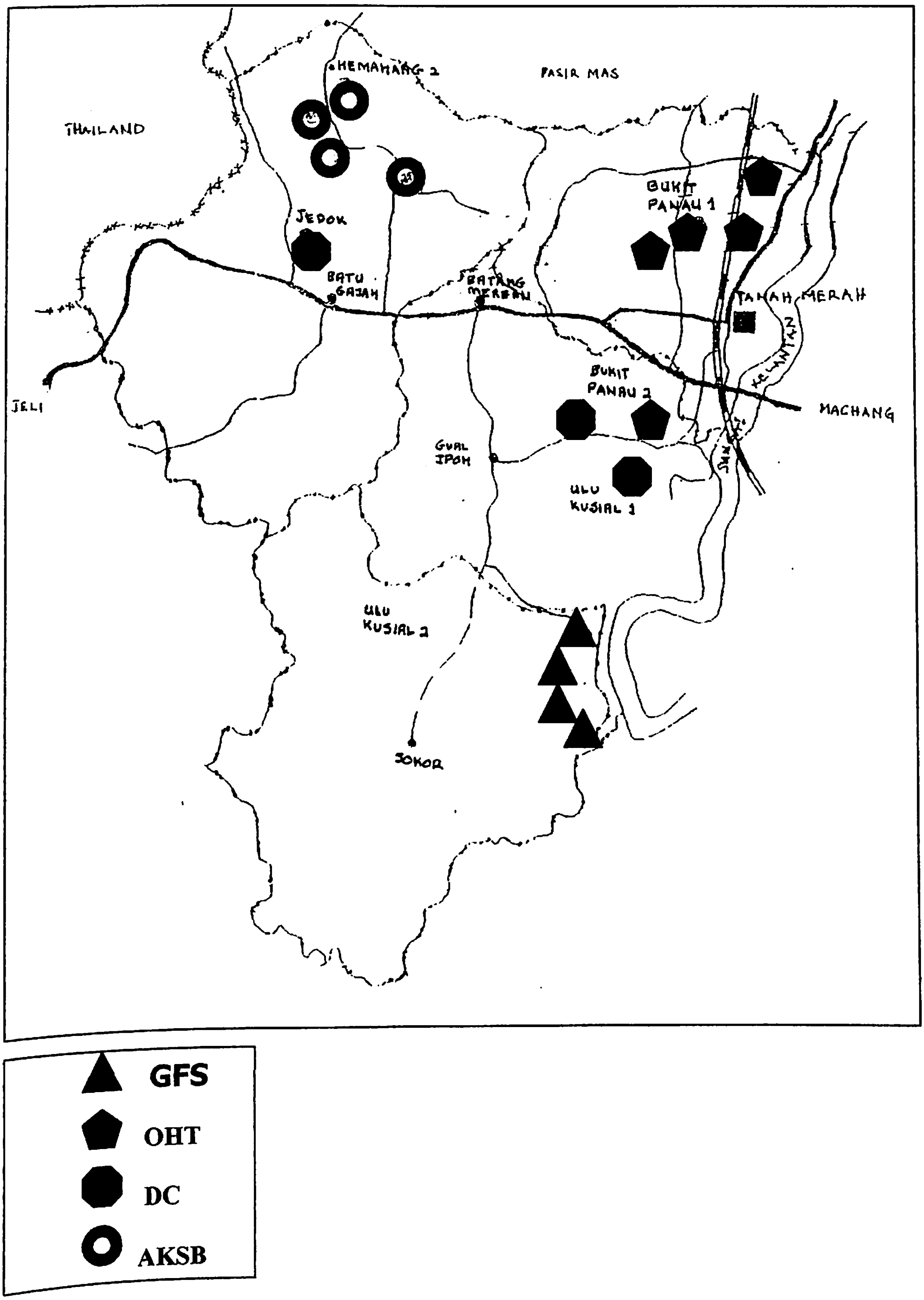
APPENDIX A: MAPS

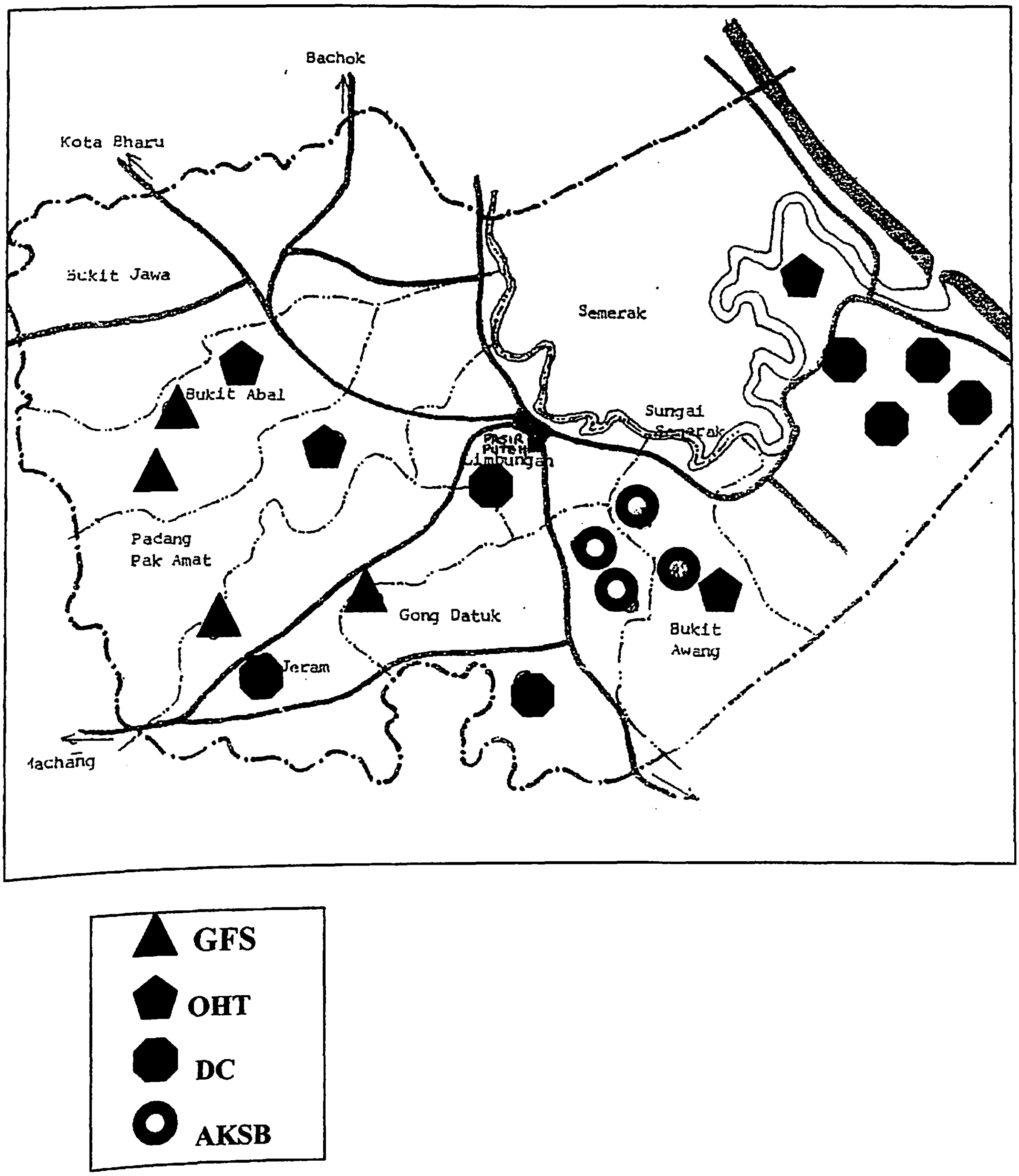
Map 1: Map of Kelantan showing Tanah Merah and Pasir Puteh districts.



Map 2: Distribution of water samples collected from 4 types rural water system in Tanah Merah, Kelantan.



Map 3: Distribution of water samples collected from 4 types rural water system in Pasir Puteh, Kelantan.



APPENDIX B: PHOTOGRAPHS

Photograph 1: Tube well with over-head tank water system

Photograph 2: Open dug well with direct connection water system

APPENDIX C

KAJIAN POTABILITI AIR LUAR BANDAR YANG DIBEKALKAN OLEH UNIT BAKAS, KEMENTERIAN KESIHATAN MALAYSIA, DI 2 BUAH DAERAH DI KELANTAN.

KETUA PENYELIDIK:
DR. ABDUL MANAF BIN HAJI HAMID

PENYELIDIK BERSAMA:
DR. SHARIFAH MAHANI BT SYED MAHAR AFFANDI

KAWASAN KAJIAN:
TANAH MERAH DAN PASIR PUTEH

INSTITUSI YANG TERLIBAT:
USM DAN KKM

BORANG KAJI SELIDIK KAJIAN TENTANG KEBERSIHAN AIR LUAR BANDAR YANG DIBEKALKAN OLEH UNIT BAKAS, KEMENTERIAN KESIHATAN MALAYSIA, DI 2 BUAH DAERAH DI KELANTAN.

BAHAGIAN 1 ~ Perlu diisi oleh pengguna

* TANDAKAN √ PADA JAWAPAN YANG BERKENAAN.

1. Nama:...

2. Alamat/ Lokaliti:...

....

3. Daerah : T. Merah ⬭ P.Puteh ⬭

4. Bilangan ahli keluarga dalam rumah: ....orang

5. Jenis bekalan air yang utama digunakan:
   a. air bukit (gravity feed system) 1 ⬭
   b. telaga tiub dengan tangki (over head tank) 2 ⬭
   c. telaga kerek dengan sambungan terus (direct connection) 3 ⬭
   d. lain-lain (nyatakan..)4 ⬭

6. Bilangan sambungan paip yang dilakukan di rumah: .... buah

7. Berapa lama menggunakan ?..........tahun

8. Adakah bekalan air sentiasa mencukupi ?:
   a. Ya ⬭ 0
   b. tidak ⬭ 1

9. Jika **tidak**, berapa kerap kekurangan/ ketiadaan air:
   a. ....kali/hari ⬭
   b. ....kali/minggu ⬭
   c. ....kali/bulan ⬭
   d. tidak menentu (nyatakan sebabnya.......................................)

10. Adakah anda berpuashati dengan mutu air tersebut dari segi:
   a. bau ya ⬭ 0 tidak ⬭ 1 (nyatakan..........)
   b. rasa ya ⬭ 0 tidak ⬭ 1 (nyatakan..........)
   c. warna ya ⬭ 0 tidak ⬭ 1 (nyatakan..........)
   d. lain-lain (nyatakan ....)

11. Anggaran bayaran bil bulanan untuk mendapatkan sumber air :
   Paling sedikit (minima): RM...........
   Paling banyak (maxima): RM...........

12. Pernahkah anda mengalami masalah kesihatan sepanjang penggunaan air tersebut:
  a. Pernah ⬭ 0
  b. tidak pernah ⬭ 1

13. Jika pernah, nyatakan tanda (atau tanda-tanda) penyakit yang anda percayai berpunca dari air tersebut;
(nyatakan...)

14. Adakah anda mahu projek bekalan air in diteruskan atau diberhentikan ?
  a. Diteruskan ⬭ 0
  b. diberhentikan ⬭ 1

15. Adakah anda menggunakan air dari sumber lain?
  a. Ya ⬭ 0
  b. tidak ⬭ 1

16. Jenis **YA**, nyatakan punca air tersebut :
  a. Telaga terbuka terkawal ⬭
  b. Telaga terbuka tidak terkawal ⬭
  c. Air sungai ⬭
  d. Air hujan ⬭
  e. lain-lain (nyatakan...)

17. Mengapa anda menggunakan air dari sumber lain?
a. air dari sumber utama tidak mencukupi ya ⬭ 0 tidak ⬭ 1
b. lebih murah ya ⬭ 0 tidak ⬭ 1
c. lebih mudah ya ⬭ 0 tidak ⬭ 1
d. lebih bermutu ya ⬭ 0 tidak ⬭ 1
e. lain-lain sebab (nyatakan..)

18. Sebarang cadangan untuk menaikkan mutu bekalan air yang dibekalkan oleh unit BAKAS, KKM.
....
....
....
....
....

Nama penyoalselidik :
Tandatangan dan tarikh:

BAHAGIAN 2

BORANG PERSAMPELAN AIR

- *PERLU DIISI OLEH PENGAMBIL SAMPEL AIR*

1. Nama pengguna:…………………………………………………………………..

2. Alamat/ no. rumah:………………………………………………………………..
…………………………………………………………………

3. No stesen/ system: ……………………………………………………………….

4. No. makmal:……………………………………………………………………..

5. Tarikh / masa pengambilan sampel:………………………………………………

6. Jenis sumber air:
   a. air bukit ⬭
   b. telaga tiub dengan tangki ⬭
   c. telaga kerek dengan sambungan terus ⬭
   d. lain-lain (nyatakan…………………………………………………………..)

7. Bilangan rumah yang dibekalkan untuk setiap satu stesen/ system:………..rumah

8. Jarak rumah pengguna dari stesen/sistem air:………………meter.

9. Sampel air di ambil dari kepala paip:
a. luar rumah ⬭
b. sinki ⬭
c. bilik air/ tandas ⬭
   d. lain-lain (nyatakan…………………………………………………………….)

10. **Jumlah nombor risiko :……….**
   (rujuk kepada **Bahagian 3~ Kajian kebersihan sistem air**):

Nama & Tandatangan pengambil sampel:………………………

BAHAGIAN 3

KAJIAN KEBERSIHAN KE ATAS SISTEM AIR

A : SISTEM "GRAVITI FEED" (AIR BUKIT) ***KK/LB-1***

- KAWASAN TADAHAN **RISIKO**

	YA	TIDAK
1. Adakah kawasan tadahan melebihi 5 hektar?		
2. Adakah aktiviti pembalakan dijalankan di kawasan tadahan?		
3. Adakah aktiviti pertanian dijalankan di kawasan tadahan?		
4. Adakah aktiviti ternakan dijalankan di kawasan tadahan?		
5. Adakah terdapat aktiviti manusia di kawasan tadahan?		
- EMPANGAN		
6. Adakah kawasan empangan tidak dipagari dengan sempurna?		
7. Adakah tidak terdapat kemudahan untuk membuang mendapan dari kawasan empangan?		
- PAIP AGIHAN DARI SUMBER KE KAMPUNG.		
8. Adakah paip agihan terdedah ?		
9. Jika ada ' break-preasure tank', adakah ia terbuka dan terdedah kepada pencemaran?		
10. Adakah dinding 'break-preasure tank' retak?		
11. Adakah tekanan air rendah di penghujung paip?		
12. Adakah sambungan haram di sistem pengagihan?		

13. Adakah paip-paip pengagihan melalui parit air limbahan atau kandang binatang ternakan ?

14. Adakah paip getah disambung ke pili dan hujungnya dibiarkan samaada atas tanah/ dalam longkang/ dalam baldi?

15. Adakah kebocoran berlaku di paip-paip pengagihan atau pili-pili?

- JUMLAH NOMBOR RISIKO: ....

- CADANGAN:

Risiko-risiko berikut adalah dikenalpasti & pengguna disyorkan untuk memperbaiki keadaan.

Nyatakan risiko untuk dikontaminasi

RENDAH	SEDERHANA	TINGGI

Nama & Tandatangan IK/PKA:..
....

B. *SISTEM TELAGA GALI/ TELAGA TERBUKA SAMBUNGAN TERUS KE RUMAH*

KK/LB-2

Maklumat am:

i. kedalaman telaga : ....meter

ii. paras air musim hujan:...........meter

iii.paras air musim panas: ....meter

iv. Adakah air telaga dicampurkan dengan klorin secara berkala?

a. ya ⬭ 0
b. tidak ⬭ 1

- KEBERSIHAN SEKELILING PERIGI	**RISIKO YA**	**TIDAK**
1. Adakah terdapat tandas di kawasan sekitar 15 meter dari telaga ?	⬭	⬭
2. Adakah tandas terdekat dibina di atas tanah yang lebih tinggi daripada telaga?	⬭	⬭
3. Adakah terdapat sebarang punca pencemaran lain di sekitar 10 meter dari telaga ?	⬭	⬭
4. Adakah terdapat air bertakung di sekitar 2 meter dari lantai konkrit telaga ?	⬭	⬭
5. Adakah pagar di sekeliling perigi tidak mencukupi untuk menghalang haiwan masuk ke dalam?	⬭	⬭
6. Adakah baldi & tali masih digunakan & diletak merata-rata dalam keadaan yang mungkin dapat dicemari?	⬭	⬭
- REKABENTUK BINAAN PERIGI		
7. Adakah lantai konkrit yang dibina di sekeliling pam lektrik kurang dari 1 meter?	⬭	⬭
8. Adakah terdapat keretakan pada lantai konkrit di sekeliling telaga?	⬭	⬭

9. Adakah saliran air pada pam lektrik rosak? ⬭ ⬭

10. Adakah sambungan antara pam lektrik kepada dasar longgar? ⬭ ⬭

11. Adakah dinding parapet di keliling telaga yang menghalang air permukaan dari masuk ke dalam telaga tidak mencukupi? ⬭ ⬭

12. Adakah keadaan dinding telaga sedalam 3 meter di bawah tanah tidak mampu menghalang air permukaan masuk ke dalam telaga atau pun pecah? ⬭ ⬭

- SISTEM RANGKAIAN

13. Adakah tangki simpanan digunakan terbuka dan terdedah kepada pencemaran? ⬭ ⬭

14. Adakah paip PVC terdedah ? ⬭ ⬭

15. Adakah paip-paip pengagihan melalui parit air limbahan atau kandang binatang ternakan? ⬭ ⬭

16. Adakah paip getah disambung ke pili dan penghujungnya dibiarkan samaada atas tanah/ dalam longkang/ dalam baldi ? ⬭ ⬭

17. Adakah kebocoran berlaku di paip-paip pengagihan atau pili? ⬭ ⬭

- JUMLAH NOMBOR RISIKO: ......
-CADANGAN:

Risiko-risiko berikut adalah dikenalpasti & pengguna disyorkan untuk memperbaiki keadaan.

Nyatakan risiko untuk dikontaminasi:

RENDAH	SEDERHANA	TINGGI

Nama & Tandatangan IK/PKA:..

C. SISTEM TELAGA TIUB DENGAN TANGKI *KK/LB-3*

Maklumat am:

i. kedalaman telaga : ....meter

ii. paras air musim hujan:...........meter

iii.paras air musim panas: ....meter

iv. Adakah air telaga dicampurkan dengan klorin secara berkala?

a. ya ⬭ 0
b. tidak ⬭ 1

- KEBERSIHAN SEKELILING PERIGI	**RISIKO**	
	YA	**TIDAK**
1. Adakah terdapat tandas di kawasan sekitar 15 meter dari telaga ?	⬭	⬭
2. Adakah tandas terdekat dibina di atas tanah yang lebih tinggi daripada telaga?	⬭	⬭
3. Adakah terdapat sebarang punca pencemaran lain di sekitar 10 meter dari telaga ?	⬭	⬭
4.Adakah terdapat air bertakung di sekitar 2 meter dari lantai konkrit telaga ?	⬭	⬭
5.Adakah pagar di sekeliling perigi tidak mencukupi untuk menghalang haiwan masuk ke dalam?	⬭	⬭
- REKABENTUK BINAAN PERIGI		
6. Adakah lantai konkrit yang dibina di sekeliling pam lektrik kurang dari 1 meter?	⬭	⬭
7. Adakah terdapat keretakan pada lantai konkrit di sekeliling pam letrik?	⬭	⬭
8. Adakah saliran air pada pam lektrik rosak?	⬭	⬭
9.Adakah sambungan antara pam lektrik kepada dasar longgar?	⬭	⬭

10. Adakah "well casing" dibina kurang dari 30 cm di atas lantai konkrit? Adakah ia pecah?

11. Adakah "casing tube" dibina kurang dari 3 meter di bawah tanah & pecah?

- SISTEM RANGKAIAN

12. Adakah tangki simpanan digunakan terbuka dan terdedah kepada pencemaran?

13. Adakah paip PVC terdedah ?

14. Adakah paip-paip pengagihan melalui parit air limbahan atau kandang binatang ternakan?

15. Adakah paip getah disambung ke pili dan penghujungnya dibiarkan samaada atas tanah/ dalam longkang/ dalam baldi ?

16. Adakah kebocoran berlaku di paip-paip pengagihan atau pili?

JUMLAH NOMBOR RISIKO:......
-CADANGAN:

Risiko-risiko berikut adalah dikenalpasti & pengguna disyorkan untuk memperbaiki keadaan.

Nyatakan risiko untuk dikontaminasi:

RENDAH	SEDERHANA	TINGGI

Nama & Tandatangan IK/PKA:..

BAHAGIAN 4

- PERLU DIISI OLEH PENGANALISA SAMPEL

1. Nama penganalisa :...

2. Tarikh / masa penerimaan sampel:...

TYPE OF ANALYSIS	PERMISSABLE LEVEL/ GUIDELINE'S VALUE	RESULT	COMMENT
a. GROUP 1 ***- microbiology***	(count/100ml)		
1. *E.coli*	0		
-physical			
2. p H	6.5-9.0		
3. Colour	15 Hazen		
4. Turbidity	5 NTU		
5. Free residual chlorine	> 0.2 mg/l		
6. Temperature	C		
7. Conductivity	100 mg/ml		
b. GROUP 2 ***- chemical***	(mg/l)		
8. Total hardness	100		
9.Total dissolved solid (TDS)	500		
10. Ammonia (NH_3)	0.5		
11. Iron (Fe)	0.3		
c. GROUP 3 ***-chemical***			
12. Sulphate (SO_4)	400		
13. Phosphorus	0.2		
14. Nitrate (N)	10		

Tandatangan penganalisa sampel:...............................

Permissible level: National Guideline for Drinking water Quality 1990 by Drinking water Quality Surveillance Unit, division of Engineering Services, Ministry of Health. Malaysia.

APPENDIX D

A STUDY ON THE POTABILITY OF RURAL WATER SUPPLIES BY BAKAS UNIT, MINISTRY OF HEALTH IN 2 DISTRICTS IN KELANTAN.

MAIN RESEARCHER:
DR. ABDUL MANAF BIN HAJI HAMID

OTHER RESEARCHER:
DR. SHARIFAH MAHANI BT SYED MAHAR AFFANDI

STUDY AREAS:
TANAH MERAH DAN PASIR PUTEH

INSTITUTIONS INVOLVED:
USM AND KKM

QUESTIONNAIRE FORM ON A STUDY ON THE POTABILITY OF RURAL WATER SUPPLIES BY BAKAS UNIT, MINISTRY OF HEALTH IN 2 DISTRICTS IN KELANTAN.

PART 1 ~ Need to be answered by the consumer

* TICK √ AT THE CHOSEN RESPONSE.

1. Name:...

2. Address/ Locality:..
....

3. District: T. Merah ⬭ P.Puteh ⬭

4. Number of family members used the water source: ....people

5. Type of main rural water system used:
   a. gravity feed system (GFS) 1 ⬭
   b. tube well with tank (over head tank- OHT) 2 ⬭
   c. Dug well with no tank (direct connection- DC) 3 ⬭
   d. others (....)4 ⬭

6. Number of tap water connection in the house: .... tap

7. For how long the consumer used the water source ?..........years

8. Is the water always enough?
   a. Yes ⬭ 0
   b. No ⬭ 1

9. If **NO**, how frequent ?:
   a... ...... times per day ⬭
   b....... times per week ⬭
   c....... times per month ⬭
   d. not regular (mention the cause.......................................)

10. Are you satisfied with the quality of the water supply in terms of :
   e. odour yes ⬭ 0 no ⬭ 1 (..........)
   f. taste yes ⬭ 0 no ⬭ 1 (..........)
   g. colour yes ⬭ 0 no ⬭ 1 (..........)
   h. others (....)

11. Payment per month for the water supply?
   Minimum pay : RM............
   Maximum pay: RM............

12. Have you experience any health effect after using the water supply?

a. yes ⬭ 0

b. no ⬭ 1

13. If **YES**, please state the symptom or symptoms;

(...)

14. Do you want this water project to be continued or stop?

a. Continue ⬭ 0

b. Stop ⬭ 1

15. Do you use other or alternative water source?

a. Yes ⬭ 0

b. no ⬭ 1

16. If **YES**, please mention the water source :

a. Sanitary well from MOH ⬭

b. Unsanitary well ⬭

c. river ⬭

d. rain ⬭

e. others (....)

17. Give reasons why you to use the alternative water source?

a. Main water source not enough	yes ⬭ 0	no ⬭ 1
b. More cheaper	yes ⬭ 0	no ⬭ 1
c. More accessible	yes ⬭ 0	no ⬭ 1
d. More quality	yes ⬭ 0	no ⬭ 1

e. Other reasons (...............................)

18. Any suggestion for the improvement of rural water project supplies by BAKAS Unit, MOH.

....

....

....

....

Interviewer :

Signature:

Date:

PART 3 :

FORM OF SANITARY SURVEY OF RURAL WATER SYSTEM

A: GRAVITY FEED SYSTEM ***KK/LB-1***

- CATCHMENT AREA

	RISK YES	NO
1. Is the catchment area more than 5 hectors?	⬭	⬭
2. Is there a risk of landslide or mudflow? (causing deforestation) in the catchments area?	⬭	⬭
3. Is there any crop production or industrial pollution upstream?	⬭	⬭
4. Are there any farms animals upstream, polluting the source?	⬭	⬭
5. Is there any human habitation upstream, polluting the source?	⬭	⬭

- DAM

6. Is the dam area unfenced?	⬭	⬭
7. Is there no facility for removing the sand/ any blocking?	⬭	⬭

- PIPED DISTRIBUTION FROM WATER SOURCE TO THE VILLAGE.

8. Is the distribution pipe exposed?	⬭	⬭
9. If there are any pressure break boxes/ tank , are their covers exposed or unsanitary?	⬭	⬭
10. Is the wall of pressure break boxes cracked?	⬭	⬭
11. Is the water pressure low at the end of the distribution pipe?	⬭	⬭
12. Is there any illegal water connection?	⬭	⬭

PART 3 :

FORM OF SANITARY SURVEY OF RURAL WATER SYSTEM

A: GRAVITY FEED SYSTEM ***KK/LB-1***

- CATCHMENT AREA	RISK YES	RISK NO
1. Is the catchment area more than 5 hectors?	⬭	⬭
2. Is there a risk of landslide or mudflow? (causing deforestation) in the catchments area?	⬭	⬭
3. Is there any crop production or industrial pollution upstream?	⬭	⬭
4. Are there any farms animals upstream, polluting the source?	⬭	⬭
5. Is there any human habitation upstream, polluting the source?	⬭	⬭
- DAM		
6. Is the dam area unfenced?	⬭	⬭
7. Is there no facility for removing the sand/ any blocking?	⬭	⬭
- PIPED DISTRIBUTION FROM WATER SOURCE TO THE VILLAGE.		
8. Is the distribution pipe exposed?	⬭	⬭
9. If there are any pressure break boxes/ tank , are thei covers exposed or unsanitary?	⬭	⬭
10. Is the wall of pressure break boxes cracked?	⬭	⬭
11.Is the water pressure low at the end of the distribution pipe?	⬭	⬭
12. Is there any illegal water connection?	⬭	⬭

B. DUG WELL/ WITH CASING ***KK/LB-2***

General information:

i. depth of the well: ....meter

ii. water level during rainy season:...........meter

iii. water level during dry seasons: ....meter

xi. Does the well on regular chlorination?
a. yes ⬭ 0
b. no ⬭ 1

- SANITATION AROUND THE WELL

	RISK YES	NO
1. Is there a latrine within 15 meters of the well ?	⬭	⬭
2. Is the nearest latrine on higher ground than the well?	⬭	⬭
3. Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 meters of the well ?	⬭	⬭
4. Is the drainage poor, causing stagnant water within 2 meters of the cement floor of the well ?	⬭	⬭
5. Is the wall or fencing around the well inadequate, allowing animals in?	⬭	⬭
6. Are the rope and bucket left in such a position that they may become contaminated?	⬭	⬭

- WELL STRUCTURE

	YES	NO
7. Is the concrete floor less than 1 meter wide all around the well?	⬭	⬭
8. Are there any cracks in the concrete floor around the well which could permit water to enter the well?	⬭	⬭

9. Is there a faulty drainage channel? Is it broken, permitting ponding?

10. Is the electric pump loose at the point of attachment to the base so that water could enter the casing?

11. Is the cover of the well unsanitary? Is the wall (parapet) around the well inadequate, allowing surface water from entering the well?

12. Are the walls of the well inadequately sealed at any point for 3 meters below ground level?

- **DISTRIBUTION SYSTEM (for direct connection)**

13. Can contaminants enter the domestic storage tank during filling? ⬭ ⬭

14. Is the PVC pipe exposed ? ⬭ ⬭

15. Is the distribution pipe cross any latrine or animal farm? ⬭ ⬭

16. Is rubber pipe connected to the tap and exposed the end for contamination from the soil/ bucket?

17. Are there any leaks in the distribution system?

- **CONTAMINATION RISK SCORE:**
- **SUGGESTION**

RISK FOR CONTAMINATION:

LOW	INTERMEDIATE	HIGH

Name & signature of the observer..
....

C. TUBE WELL SYSTEM *KK/LB-3*

General information:

i. depth of the well: ....meter

ii. water level during rainy season:...........meter

iii. water level during dry seasons: ....meter

xii. Does the well on regular chlorination?
- a. yes ⬭ 0
- b. no ⬭ 1

- SANITATION AROUND THE WELL	**RISK YES**	**NO**
1. Is there a latrine within 15 meters of the well ?	⬭	⬭
2. Is the nearest latrine on higher ground than the well?	⬭	⬭
3. Is there any other source of pollution (e.g. animal excreta, rubbish) within 10 meters of the well ?	⬭	⬭
4. Is the drainage poor, causing stagnant water within 2 meters of the cement floor of the well ?	⬭	⬭
5. Is the wall or fencing around the well inadequate, allowing animals in?	⬭	⬭
- WELL STRUCTURE		
6. Is the concrete floor less than 1 meter wide all around the well?	⬭	⬭
7. Are there any cracks in the concrete floor around the well which could permit water to enter the well?	⬭	⬭
8. Is there a faulty drainage channel? Is it broken, permitting ponding?	⬭	⬭
9. Is the electric pump loose at the point of attachment to the base so that water could enter the casing?	⬭	⬭
10. Is the well casing build less than 30 cm from the	⬭	⬭

concrete floor? Is the casing broken?

11. Is the casing tube build less than 3 meter below ground level? Is the casing broken? ⬭ ⬭

- **-DISTRIBUTION SYSTEM (for direct connection)**

12. Can contaminants enter the domestic storage tank during filling? ⬭ ⬭

13. Is the PVC pipe exposed ? ⬭ ⬭

14. Is the distribution pipe cross any latrine or animal farm? ⬭ ⬭

15. Is rubber pipe connected to the tap and exposed the end for contamination from the soil/ bucket? ⬭ ⬭

16. Are there any leaks in the distribution system? ⬭ ⬭

- **CONTAMINATION RISK SCORE:**
- **SUGGESTION**

RISK FOR CONTAMINATION:

LOW	INTERMEDIATE	HIGH

Name & signature of the observer...
....

PART 4

- NEED TO FULFILLED BY THE MOH STAF
  1. Name of the analyzer:

2. Date / time of samples acceptation:

TYPE OF ANALYSIS	**PERMISSABLE LEVEL/ GUIDELINE'S VALUE**	**RESULT**	**COMMENT**
GROUP 1 ***- microbiology***	(count/100ml)		
1. *E.coli*	0		
-physical			
2. p H	6.5-9.0		
3. Colour	15 Hazen		
4. Turbidity	5 NTU		
5. Free residual chlorine	> 0.2 mg/l		
6. Temperature	C		
7. Conductivity	100 mg/ml		
GROUP 2 ***- chemical***	(mg/l)		
8. Total hardness	100		
9.Total dissolved solid (TDS)	500		
10. Ammonia (NH_3)	0.5		
11. Iron (Fe)	0.3		
GROUP 3 ***-chemical***			
12. Sulphate ($S0_4$)	400		
13. Phosphorus	0.2		
14. Nitrate (N)	10		

Signature of sample analyzer:..............................

Permissible level: National Guideline for Drinking water Quality 1990 by Drinking water Quality Surveillance Unit, division of Engineering Services, Ministry of Health. Malaysia.

LAMPIRAN

PENGHARGAAN

Pihak penganjur mengambil kesempatan di sini untuk mengucapkan ribuan terima kasih kepada semua pihak yang telah menyumbang samada secara langsung atau tidak langsung kearah menjayakan persidangan kesihatan kali ini

PERSIDANGAN KESIHATAN NEGERI KELANTAN (HEALTH CONFERENCE KELANTAN) 2001

Anjuran:

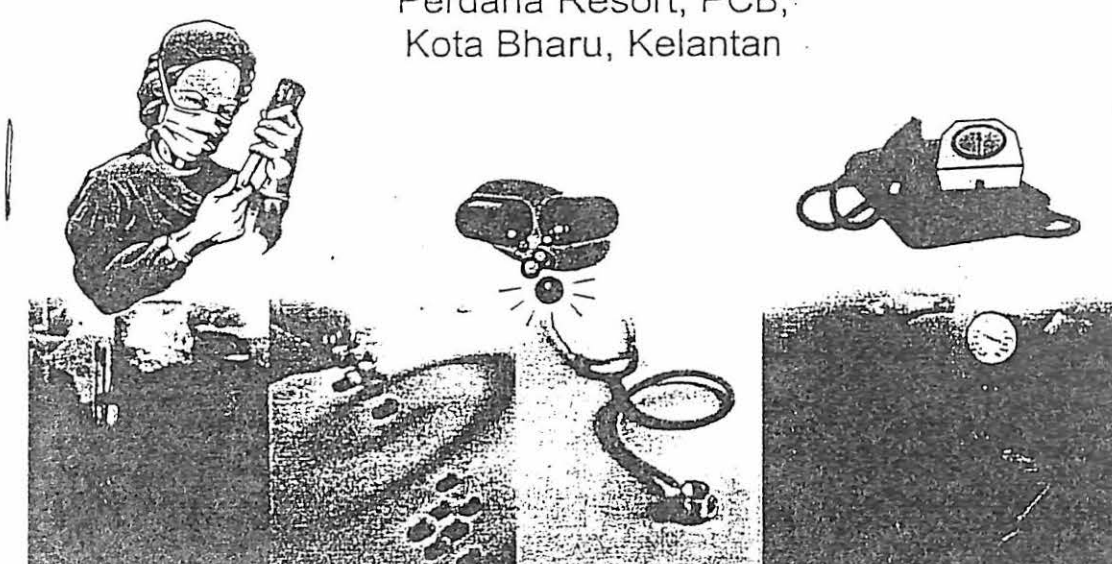
Jabatan Kesihatan Kelantan

Universiti Sains Malaysia, Caw. Kelantan

TEMA

"Perkongsian pintar kearah kesihatan untuk semua"

4 – 5 November 2001
Perdana Resort, PCB,
Kota Bharu, Kelantan



Usaha pencegahan dan kawalan bagi mempastikan penyakit FWBD tidak terus berlaku perlu dilaksanakan secara kerjasama semua pihak terutama Jabatan Kesihatan, pihak berkuasa tempatan, syarikat pembekal air masyarakat, institusi penyelidikan, pengendali makanan dan masyarakat selaku pengguna. Kerja-kerja yang telah sedia dilaksanakan seperti pemantauan tahap pencemaran makanan dan minuman yang berisiko, penguatkuasaan bersepadu, kerjasama intersektoral dan pengagihan seimbang petugas kesihatan mengikut beban kerja perlu diteruskan dan dipantau keberkesanannya. Beberapa cadangan baru juga perlu dipertimbangkan seperti memperhebatkan penyelidikan, penubuhan pusat kecemerlangan berkaitan penyakit berasaskan ceret beret (Diarrhea Diseases Center) dan pengukuhan sistem maklumat dan pengauditan program secara berkala.

P1.2
PENCEMARAN SALMONELLA SPP. DALAM AIR TELAGA DI NEGERI KELANTAN

Pn. Natrah Abu Bakar dan Norazlizawati Nawang

A total of 100 well-water were collected from Kota Bharu, Bachok, Pasir Mas and Pasir Putih district and analysed for salmonella spp. Isolation was conducted by pre-enrichment and second enrichment, selective plating, serological reaction and finally biochemical identification. All isolates were further serotyped at the Institute of Medical Research, Kuala Lumpur. Of the lot,12 samples were detected salmonella spp. and most of sampel from Kota Bharu. The most frequently serotype of salmonella were salmonella spp. unknow following by weltevreden, bovismorbificans and galiema.

P1.3
A STUDY ON THE POTABILITY OF RURAL WATER SUPPLY BY BAKAS

Dr. Sharifah Mahani Syed Mahar Affandi, Dr. Abdul Manaf Hamid

BAKAS (Water supply and environmental sanition) unit of ministry of Health was first introduced in 1974 for controlling water and vector borne diseases through supplying safe water supply and sanition facilities for rural areas. But there's no proper monitoring of the water quality like in geverment/non-government treated water plant. A cross-sectional study was conducted to study on the potability of various rural water system (Gravity Feed system, Over Head Tank, direct Connection and others(supplies by BAKAS unit in Pasir Puteh. 164 household from different villages were selected using multistage random sampling. Data were collected using a structured questionnaire, water sampling for physical, chemical and microbiology and sanitary survey to estimate the risk of water contamination. Parameters that violationare E.Coli (53.7%), pH (63.4%), colour (0.6%), turbidity (20.7%), free residual chlorine (77.4%), ammonia (5.5%), iron (6.1%) and phosphate (20.7%). Results also showed that regular chlorinating (Odds Ratio=1.19, 95% Confidence Interval=0.059-0.240 p=0.000) had significant influence on presence of E.Coli. Non-involvement of communities is still rated as a problem in Malaysia although it is not regarded as serious. National staff should now more aware of the importance of involving communities in all aspects of water supply and sanition schemes including planning, design, construction, operation and maintenance.

P2.1
INISIATIF BEKALAN AIR SELAMAT DI KELANTAN

Air Kelantan Sdn. Bhd

Abstrak tidak disertakan

P2.2
KAJIAN KAP MASYARAKAT TERHADAP PERSEKITARAN

Dr. Hanis USM

Abstrak tidak disertakan

DR. SHARIFAH MAIMANI BT SYED MAHAR AFFANDI

SOUVENIR PROGRAMME & ABSTRACTS

SYMPOSIUM ON FAMILY HEALTH AND FAMILY LIFESTYLES

25 - 26 January 2002
Grand Blue Wave Hotel,
Shah Alam, Selangor

Organized By
IRPA PROJECT
"To Study the Relationship Between Family Lifestyles and Family Health"
(06-02-05-7010)

Household Satisfactions On Rural Water Supplies By Ministry Of Health In Pasir Puteh, Kelantan.

Sharifah Mahani Syed Mahar Affandi & Abdul Manaf Hamid
Department of Community Medicines. School of Medical Sciences. Universiti Sains Malaysia.

BAKAS (Water supply and environmental sanitation) unit of Ministry of Health (MOH) was first introduced in 1974 for controlling water and vector borne diseases through supplying safe water supply and sanitation facilities for rural areas. A cross-sectional study was conducted to study on the satisfactions of various rural water system supplies by BAKAS unit in P.Puteh. 164 household from different villages were selected using multistage random sampling. Data were collected using a structured questionnaire for villages satisfactions. water sampling for physical. chemical and microbiology. and sanitary survey to estimate the risk of water contamination. Factors that contribute to the wholesome of water supply are numbers of family members (mean 5.48 ! 2.66). numbers of water tap (mean 2.99! 0.96). years of using (mean 7.36! 5.81) and numbers of houses. Results also showed that. no regular chlorinating of water system (Odds Ratio=1.19. 95% Confidence Interval=0.059-0.240. p=0.000) had significant influence on presence of *E.coli*. Thus the water supplies in Pasir Puteh is still not very satisfactory. The condition could be improved by involving communities in all aspects of water supply and sanitation. Any lack of involvement is mostly caused by insufficient health education.

Pengetahuan Dan Amalan Pelajar Sekolah Menengah Di Malaysia Tentang Bahaya Tabiat Merokok -Kajian HELIC

Faris Irfan CY[1], AMH Zabidi -Hussin[1], Mazidah AR[1], Quah BS[1], Abdul Wahab J[2], Ruzita T[3], Hafezi MZ[1], Suhaimi H[2]

[1]Universiti Sains Malaysia,[2]Universiti Islam Antarabangsa.[3]Universiti Kebangsaan Malaysia.

Kajian ini telah dijalankan di empat kawasan kajian di Semenanjung Malaysia iaitu Kelantan, Pahang, Selangor dan Kuala Lumpur untuk mengkaji tahap pengetahuan, sikap dan amalan pelajar sekolah menengah terhadap tabiat merokok. Selain itu, kajian ini juga bertujuan untuk menguji keberkesanan program intervensi yang dijalankan menggunakan modul pendidikan yang dicipta khas mengikut kurikulum sekolah. Seramai 968 orang pelajar tingkatan satu telah terlibat dengan kajian ini daripada lapan buah sekolah iaitu dua sekolah daripada setiap kawasan. Tahap pengetahuan. sikap dan amalan (KAP) tentang tabiat merokok diuji menggunakan satu set borang soal selidik. Borang soal selidik yang terdiri dari 40 soalan ini diisi sendiri oleh pelajar pada hari ujian dijalankan. Selepas mengikuti ujian KAP, pelajar-pelajar di sekolah intervensi mengikuti program intervensi selama enam minggu menggunakan modul yang disediakan. Setelah selesai program intervensi dijalankan, ujian KAP2 pula akan dilaksanakan. Keputusan daripada kedua-dua ujian intervensi ini akan dibandingkan untuk melihat keberkesanan modul intervensi yang diikuti. Berdasarkan analisis yang dijalankan selepas ujian KAP1, didapati 16.7% pelajar telah melaporkan bahawa mereka pernah mencuba rokok (88.9% lelaki dan 11.1% perempuan) manakala 3.73% merokok setiap hari, 12.42% merokok sekurang-kurangnya sebatang dalam seminggu. Peratus yang paling tinggi ialah dikalangan pelajar-pelajar di Pahang (20.3%) diikuti oleh Selangor (18.5%), Kuala Lumpur (14.3%) dan Kelantan (13.6%). Ujian KAP1 yang dijalankan menunjukkan bahawa meskipun pelajar tahu tentang bahaya tabiat merokok. pengetahuan ini tidak dipraktikkan. Hasil daripada program intervensi yang dijalankan, didapati pelajar yang mengikuti program intervensi mempunyai purata markah ujian yang tinggi semasa ujian KAP2 ($K2=31.98 \pm 6.62$, $A2=49.82 \pm 5.82$, $P2=26.33 \pm 3.40$) berbanding KAP1 ($K1=28.9 \pm 7.96$, $A1=47.45 \pm 6.37$, $P1=25.82 \pm 3.8$) dengan perbezaan yang sangat ketara ($p \leq 0.05$). Perkembangan ini diharapkan dapat juga mengubah konsep dan persepsi pelajar terhadap tabiat merokok seterusnya menjauhi tabiat buruk itu. Ini akan dipastikan melalui ujian susulan (KAP3) yang akan dilaksanakan dalam tempoh enam bulan dari tarikh ujian KAP2.

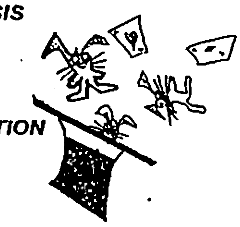
A STUDY ON THE POTABILITY OF RURAL WATER SUPPLIES BY "BAKAS" UNIT, MINISTRY OF HEALTH IN TANAH MERAH AND PASIR PUTEH DISTRICTS, KELANTAN.

DR. SHARIFAH MAHANI SYED MAHAR AFFANDI
MASTER OF COMMUNITY MEDICINE (ENVIRONMENTAL HEALTH)

SUPERVISOR:
PROF. MADYA DR. ABDUL MANAF B. HJ. HAMID
DEPARTMENT OF COMMUNITY MEDICINE
USM . KELANTAN.

Journal Club
19.9.2002

CONTENTS:



INTRODUCTION

- Water is an essential nutrient.
- Each person drinks an average of 2.0 litres of fluids daily; depending on body size, body metabolism, physical activity and environmental conditions. The quality and the potability of water is very important, as contaminated water *may cause food and water–borne diseases, skin,eyes* disorder and other organ problem
- (Shukur,1997)
- *Physical, chemical and microbiology contamination* emanating from natural geological sources, agricultural and industrial activities has to be monitored to ensure wholesome of drinking water and safety to consumers.
- Water is potable when it is free from apparent colour, *turbidity,odor & objectionable taste*, carcinogenic, mutagenic or neurotoxic substances.

(Akbar,1989).

There are 3 crucial concerns in relationship between water and health :

- 1. The constraints faced by water-poor countries and their impact on human activities.
- 2. The maintenance of water quality in the face of growing demand.
- 3. The direct link between health and water, especially concerning diseases associated with insufficient and poor-quality water and with inadequate provision for the disposal of wastewater.

(WHO,1992)

WHY RURAL WATER SYSTEM?

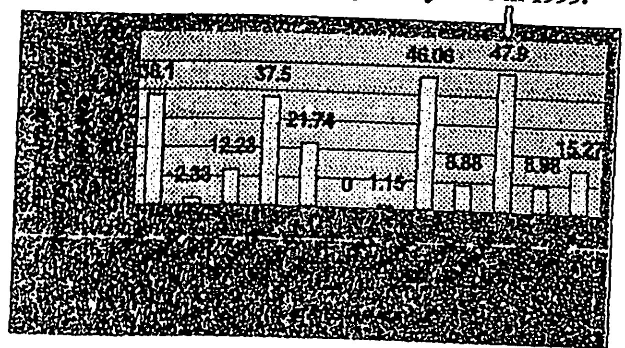
- *More than 1 billion people have no access to an adequate and* safe water supply, and a variety of physical, chemical and biological agents render many sources unhealthy. More than 800 *million of those undeserved live in rural areas* (WHO,1998).
- MOH intensifying the surveillance programmes both in *urban and rural areas in order to fulfill the expected* increased demands for potable water with the rapid expansion of economic development in the country.

What is BAKAS unit, Ministry of Health?

- "Water supply and environmental sanitation"
- for controlling water and vector-borne diseases through supplying safe water supply and sanitation facilities for rural areas.
- BAKAS rural projects for water supply are;
  1. Gravity feed system(GFS)*
  2. Sanitary wells ~ Overhead tank(OHT)* and Direct connection(DC)*
  3. Rainwater collection
  4. Government/ NGO water connection~ Air Kelantan Sdn Bhd (AKSB)
  5. others

(Engineering Services Division, MOH, 1999)

Figure 1: Percentage of unsatisfactory (not potable) water sampling from MOH projects by state in 1999.



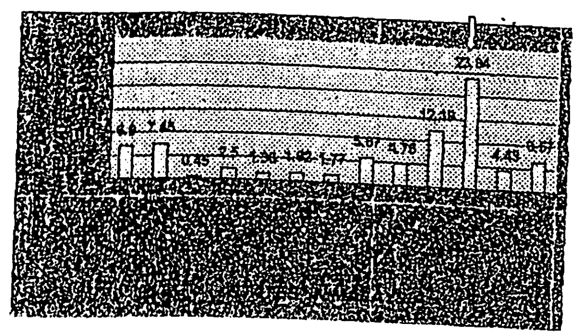
Source: Annual report on BAKAS programmes, Engineering unit, Ministry of Health, 2000.

Table 1 :Percentage of houses with rural water supply and percentage of houses with unsafe water in Kelantan.

TYPE OF WATER SUPPLY	1998	2000
MOH (BAKAS PROJECT)	28.84	13.72 ⇓
AIR KELANTAN SDN BHD	34.22	40.53 ⇑
OTHER AGENCIES	11.70	10.69 ⇓
UNCLEAN WATER SUPPLY	25.24	35.06 ⇑

Source: State Health Director Office ,1998 & 2000

Figure 2: Percentage of houses in rural areas with unsafe water supply by state in 1999.



Source: Annual report on BAKAS programmes, Engineering unit, Ministry of Health, 2000.

TYPES OF RURAL WATER SYSTEM CONCERNED IN THIS STUDY.

. *GRAVITY FEED SYSTEM~*

- provides untreated water to the rural communities, using spring ...ater from uninhabited catchments areas, which are relatively free ...om contamination (*MOH, 1983*).
- constructed with a *hillside* concrete and *stone silt box* connected ..., an underground pipe to a village tap.
- water sources (reservoir) located higher level (e.g hills, mountain) ...an consumer & use gravity for the water to flow.
- ...an supply from 50 to 300 houses depending on capacity of the ...ter flow continuously, the size of the pipe and optimum pressure.

Gravity feed system

2. TUBE WELL WITH OVER HEAD TANK~

- drilled type is chosen because these types of tube well are nearly always potable when constructed and located to prevent pollution (Lehr *et al*, 1980).
- can supply from 4 to 50 houses depending on the depth of the well & water level
- use electric pump
- maximum depth ~ 30 meters

3. OPEN DUG WELL WITH DIRECT CONNECTION (NO TANK)~

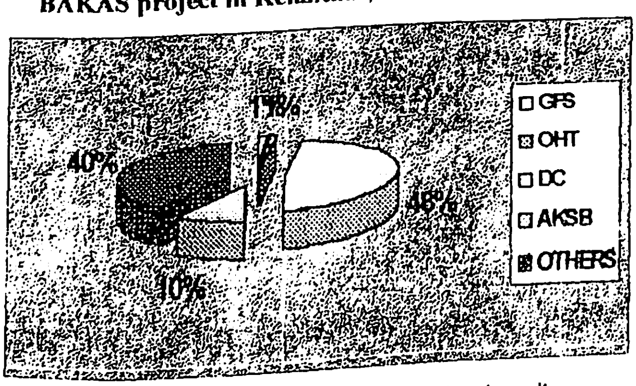
- The cheapest type of well construction and can be done manually by villagers.
- supply 1 to 2 houses
- use electric pump
- up-grading from unsanitary well to sanitary well (with proper apron, proper drain etc).
- The well depth can be as about 6 to 15 meters depends on type of soil. The diameter of the well usually 90 to 120 centimeters.

4. AIR KELANTAN SDN. BHD. (AKSB) WATER CONNECTION

- AKSB water connection was purposely chosen for "other" types of rural water system.
- This system produced treated water with a conventional method involving process of aeration, flocculation, sedimentation, filtration and chlorination.
- BAKAS unit provided all the piping and water connection from *the main pipe to the consumer house (not directly under BAKAS* project).The consumers only need to pay the water bills every month to AKSB.
- In Tanah Merah there are 6 water treatment plants whereby in Pasir Puteh, only 1 water treatment plant available.

Water treatment plant

Figure 3: Percentage of rural water system by BAKAS project in Kelantan , 1999



Source: Annual report on BAKAS programmes, Engineering unit, Ministry of Health, 2000.

LITERATURE REVIEW

1. Drinking Water Quality Standard (WHO, 1983)~ drinking water must be clear, colourless and odourless. It must be pleasant to drink and free from all harmful organisms, chemical substances and radionucleides in which could constitute a hazard to the health of the consumer. The quality of drinking water is measured in terms of its physical, chemical, radiochemical and microbiological characteristics.
2. The challenges confronting the water supply sector in Malaysia is not only to ensure that it is adequate and continuous water supply to all residents but also to ensure that it is able to meet the ever more stringent water quality standards consistency (Tan,1997).
3. Study by Hayati (2000), in Pendang , Kedah showed that 66.7% of the water samples taken from 39 open dug well were contaminated with coliform. There was a relationship between bacteria contamination and the depth of the well, distant from septic tank, apron conditions and the use of electric water pump.

4. *Escherichia coli*, is the microbiological indicators of choice for drinking water potability especially in developing countries with limited resources (WHO, 1993).

5. The practice of boiling water needs to be accompanied with other aspects of hygiene and type of water supply influenced significantly the presence of bacteria (Win Kyi *et al*, 1990).

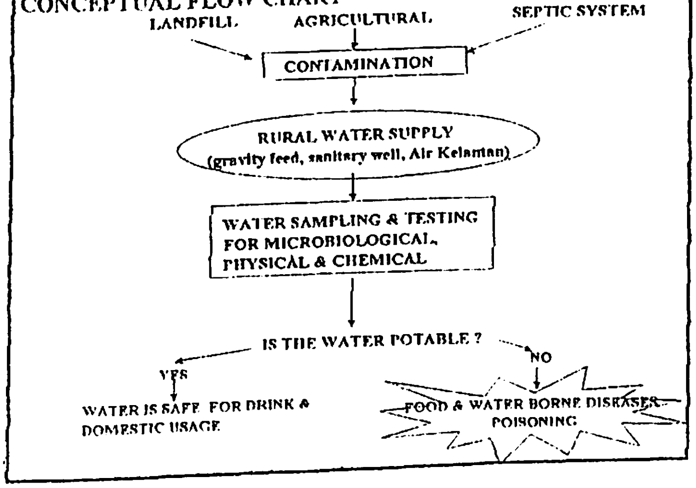
6. Water management is becoming increasingly comprehensive and complicated due to larger concentrations of population, commercial activities and industries around the cities and towns, increasing water consumption, increasing water pollution, increasing land use conflicts and climate changes (Azhari, 1999).

JUSTIFICATION OF THE STUDY

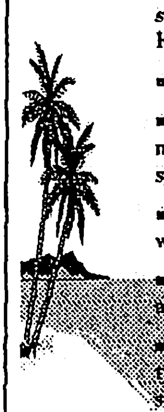
- Drinking water monitoring is one of the interesting subjects in environmental health and water quality is an important issue for many years especially in Kelantan. At present, the monitoring and surveillance programme is limited to urban distribution system and some remote systems in plantation.

- This is only an exploratory study.No similar study has been done before and there is no baseline data available. Thus, this study will further extend to include all types of public water supplies in rural areas.

CONCEPTUAL FLOW CHART



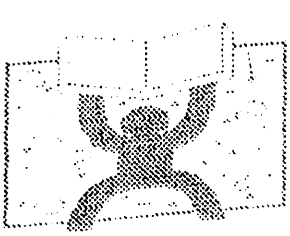
OBJECTIVES:



- A. General: To study the potability of rural water supplies by BAKAS unit, Ministry of Health in Kelantan.
- B. Specific:
- 1. To assess the physical, chemical & microbiological parameters of 4 types of rural water systems in Tanah Merah and Pasir Puteh districts.
- 2. To compare the potability of 4 types of rural water systems.
- 3. To study the consumer satisfaction on the quality and quantity of rural water supply.
- 4. To determine the risk of contamination for each type water system based on total sanitary survey score and *E.coli* calculation.

HYPOTHESIS

- 1. There is a difference in the potability of drinking water from the 4 types of rural water supplies.



METHODOLOGY

▪ RESEARCH DESIGN:

- *~CROSS SECTIONAL STUDY*
- *~STUDY PERIOD: 16.8.2000 TILL 29.7.2001*

▪ REFERENCE POPULATION:

- All houses in the rural area that received water supply from Kelantan BAKAS project.

▪ STUDY POPULATION :

- Houses received water supply from BAKAS rural projects in Tanah Merah & Pasir Puteh. All houses are numbered by the Public Health Inspector (PHI) according to their map in selected village.

▪ SAMPLING METHOD:

- multistage random sampling

▪ SAMPLE SIZE CALCULATION:

- using two proportion formula (Dobson,1984)~ minimum 252 samples

SAMPLING METHOD:

MULTISTAGE RANDOM SAMPLING

KELANTAN

1st stage ⇩ (by random sampling)

6 DISTRICTS

(with all 4 types of water supplies available)

2nd stage (by random sampling)

PASIR PUTEH | TANAH MERAH

3rd stage ⇩ (by random sampling) ⇩

VILLAGE/MUKIM | VILLAGE/MUKIM

GFS OHT DC AKSB | *GFS OHT DC AKSB*

Map of Kelantan

Percentage of potable water samples from OHT water system = 51.85%
Percentage of potable water samples from DC water system =25.00%
No data available for GFS and AKSB.

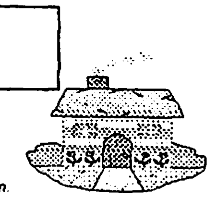
(P.Puteh district health office, 1999)

P_1 (Proportion of potable water samples from OHT water system) = 0.52
P_2 (Proportion of potable water samples from DC water system) =0.25
Z_α (Confidence interval of 95%)= 1.96
Z_β *(Power of the study 90%)*= 1.28

By using two proportions formula,

$$\text{Sample size},n = \frac{P_1(1-P_1)+P_2(1-P_2)}{(P_1-P_2)^2}\quad (Z_\alpha . Z_\beta)^2$$

$$n= \frac{0.52(1-0.52)+0.25(1-0.25)}{(0.52-0.25)^2}\quad (1.96+1.28)^2$$



= *63 water samples from each types of rural water system.*
So the minimum total sample size needed was 252 (1 to 1 ratio).

RESEARCH INSTRUMENTS

★ (3 methods)

1. By using survey form- questionnaire were asked from selected houses for baseline household data & their satisfaction on the water quality *(taste, odour, colour)* and quantity~ 15 questions (WHO, 1997).

2. By water sampling and analysis- taken from interviewed household and analyzed on field /drinking water quality control (KMAM) laboratory at the Health Office ~ 14 parameters were tested and the results were compared with the permissible level from Ministry of Health .

3. By using standard sanitary survey form to determine the level of risk for contamination- prepared by Engineering Services Division, MOH~ specific check list for each water system.

★ GFS~ 15 items (KK/LB-1)

★ OHT~ 16 items (KK/LB-3)

★ DC ~ 17 items (KK/LB-2)

DATA COLLECTION AND HANDLING:

All houses in the selected villages were mapped & numbered accordingly by the PHI and his assistant. Selection of the houses by random sampling.

They interviewed selected household regarding water quality & quantity.

The water samples were taken from the water tap & analyzed on field for the chemical, physical and microbiological parameters by using standard measures/ instrument as in table 3.

A total of 325 samples (161~ T.Merah & 164~ P.Puteh) were collected from 16.8.2000 till 29.7.2001.

Table 2: List of parameters tested, the descriptions and adverse effect

PARAMETERS	SOURCES/ DESCRIPTION	NEGATIVE HEALTH EFFECT
Microbiology 1. *Escherichia coli*	Human and warm blooded mammals fecal waste.	Can cause diarrhea, cramps, nausea, headache and other symptoms. Used as an indicator that other potentially harmful bacteria may be present.
Physical 2. pH	Very important parameter to ensure satisfactory waters clarification and disinfection.	No direct impact. Extreme values of pH can result in the contamination of drinking water and in adverse effects on its taste, odour and appearance.
3. colour	Due to presence of coloured organic matter (primarily humic and fulvic acids) associated with the humus fraction of soil (strongly influenced by iron and other metals).	No health effects but may be the first indication of a hazardous situation.

Table 2 continued

4. turbidity	Soil runoff	No health effects but can interfere with disinfection and provide a medium for microbial growth.
5. free residual chlorin	Chlorine is the main disinfecting agent.	Adverse effect with the chlorine by products.
6. temperature	-	No health effect. Cool water is generally more palatable than warm water. High water temperature enhances the growth of microorganisms and may increase taste, odour, colour and corrosion problems.
7. conductivity	Related to TDS, depends on chemical composition and ionic charges on water ions.	Add in producing dissolved solids and concentration of minerals

Table 2 continued

Chemical		
8. total hardness	Calcium and magnesium dissolved in water are the two most common minerals that make water "hard"	Hard water is not a health risk, but nuisance because of mineral buildup on fixtures and poor soap / detergent performance. Deposits in pipes may reduce water flow.
9. total dissolved solid – comprise inorganic salts (eg: calcium, magnesium, potassium, bicarbonates, chlorides, sulfates) and small amounts of organic matter that are dissolved in water.	Originate from natural sources, sewage, urban run-off and industrial wastewater. Concentration of TDS depends on geological regions owing to differences in solubility of minerals.	No health effects. However, the presence of high levels of TDS in drinking water may be objectionable to consumers.
10. ammonia	Originates from metabolic, agricultural and industrial processes and from disinfection with chloramine.	Not of immediate health relevance but concentration of > 1.5 mg/l may cause odour problem and > 35 mg/l may cause taste problems. It may also compromise disinfection efficiency.

Table 2 continued

11. iron	Natural deposits, corroded metal distribution pipes	No health effects but can facilitates the growth of 'iron bacteria' and high level may effect taste and may cause staining.
12. sulphate	Natural deposits, steel and metal industries, fungicide manufacturing	Have a laxative effect (diarrhea) that can lead to dehydration especially in infants.
13. phosphorus	Natural deposits, in fertilizer are called superphosphate	Inflammation of mucous membrane, dermatitis, conjunctivitis
14. nitrate	Runoff from fertilizer use, leaching from septic tanks, sewage, erosion of natural deposits	Methemoglobulinemia or "Blue baby syndrome" in infants under 6 months

Source: Guidelines for drinking-water quality, WHO,1996.

Table 3: Permissible level by MOH, the instruments and the reagent used for each item.

TYPE OF ANALYSIS	PERMISSABLE LEVEL BY MOH	INSTRUMENTS	REAGENT/ CHEMICAL
1. GROUP 1			
-BACTERIAL Faecal coliform (specific for E.coli)	0	Millipore filtration set (Whirl-pack thio bags, pesterilized petri pad)	Media Culture Broth
- PHYSICAL			
pH	6.5-9.0	Hach pH Meter (43800-00)	Buffer powder pillows
Colour	15 Hazen	Colour Comparator	-
Torbidity	5 NTU	Torbidimeter(2100P)	Silicon oil
Free residual Chlorine	>0.2mg/l	Hach Model DR 2000 Spectrophotometer	Dieltyl para-phenylene diamine(DPD) free chlorine
Temperature	°C	Temperature meter	-
Total Hardness	100mg/l	(by manually)	Tiraver EDTA solution, Manver 2 Hardness powder pillow.
Conductivity	100 mg/l	Conductivity meter(44600)	-

Table 3: continued

2. GROUP 2			
- CHEMICAL	(mg/l)		
Total dissolved solid	500	TDS METER(44600)	-
Ammonia (NH_3)	0.5	DR 2000	Deionized water, mineral stabilizer, polyvinyl alcohol, Nessler reagent
Iron (Fe)	0.3	DR 2000	Ferrous iron reagent powder pillow
3. GROUP 3			
- CHEMICAL			
Sulphate(SO_4)	400	DR 2000	Sulfaver 4 sulfate powder pillow
Phosphate	0.2	DR 2000	Phosvers 3 phosphate poedor pillow
Nitrate	10	DR 2000	Nitrate 5 nitrate powder pillow

(National Guidelines for Drinking Water Quality, MOH, 1996)

Table 4: Level of risk for contamination

Type of water supply	Total Sanitary Risk Score		
	Low Risk	Intermediate Risk	High Risk
GFS	0-3	4-7	8-15
OHT	0-3	4-7	8-16
DC	0-3	4-7	8-17

Source: Guidelines for drinking-water quality: Surveillance and Control of Community Supplies. WHO.1997

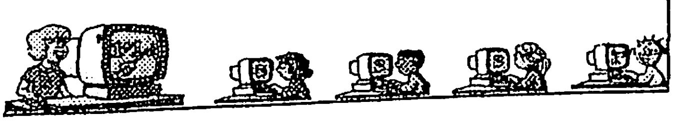
TABLE 5 : ASSESSMENT OF PRIORITY OF REMEDIAL ACTIONS BY RISK ANALYSIS

E. Coli Classification Count per 100 ml		Sanitary inspection risk score: 0	1	2	3	4	5	6	7	8	≥9
>1000	E										
100-1000	D										
10-100	C										
1-10	B										
0	A										
		No action required	Low risk: Low action priority			Intermediate risk: Higher action priority			Very high risk: Urgent action		

Source: Guidelines for drinking-water quality: Surveillance and Control of Community Supplies. WHO.1997

STATISTICAL ANALYSIS

- Data were entered and analyzed by Statistical Package for *Social Sciences (version 10.0)*.
- Use of univariate analysis to compare the water potability from the 4 types of water supply.
- Descriptive statistics~Means,median,standard deviations and interquartile range were calculated for all numericals variables
- *Inferential statistics~Chi-square, Fisher Exact, One-way* ANOVA and Kruskal Wallis non-parametric test were used with p value < 0.05 indicates statistical significance.
- Percentages of violation in the water samples were compared with the drinking water standard from MOH.



LIMITATIONS

1) Intra-observer and inter-observer bias
- Method/technique of water sampling (different sample collectors in each districts).
- Sanitary survey was determined only by observational.

2) Instrumental bias- different districts have different calibration of laboratory kit used.To overcome ~ used the same intruments for both districts

3) Some of the selected household were not at home during the sampling time , so need to come another day.

4) Prolong rainy season and flood from November 2000 till January 2001, so data cannot be collected at that time because it will interfere the water analysis. Potability would be expected to deteriorate during rainy months since bacterial contamination of groundwater generally increases after heavy rains (Kravitz, 2000).

RESULT

Table 6: Study areas in Tanah Merah and Pasir Puteh

TYPE OF RURAL WATER SYSTEM	SELECTED VILLAGES IN TANAH MERAH	TOTAL HOUSES	SAMPLE HOUSES	SELECTED VILLAGES IN PASIR PUTEH	TOTAL HOUSES	SAMPLED HOUSES
1. OVER HEAD TANK (OHT) - TUBE WELL WITH A TANK	BKT PANAU 1-	44	33	BUKIT ABAL-	40	10
	BKT PANAU 2- BKT MERAH	7	7	BUKIT AWANG-	63	10
				PDO PAK AMAT-	84	10
				SEMARAK-	37	10
	TOTAL	*51*	*40*	*TOTAL*	*223*	*40*
2. DIRECT CONNECTION/ NO TANK (DC) - OPEN WELL WITH NO TANK	ULU KUSIAL 1-	20	11	JERAM	84	12
				GONG KETEREH	8	6
	BKT PANAU 2-	22	19	CERANG RUKU	31	25
	JEDOK-	23	10			
	TOTAL	*65*	*41*	*TOTAL*	*123*	*43*
3. GRAVITY FEED SYSTEM (GFS)	ULU KUSIAL 2-			BKT ABAL		
	a KUALA LAKAR	5	4	a PERMATANG SUNGKAI	120	10
	b TEGEWANG	29	14	b KG. BENDANG	81	10
	c CEGAR NERAK	32	11			
	d SOKOR BARU	39	12	JERAM- KG TELOSAN	215	11
	TOTAL	*105*	*41*	GONG DATUK KG.TAWER	66	10
				TOTAL	482	*41*
4. AKSB WATER CONNECTION	JEDOK-			C[illegible]AL-		
	a FELDA KEMAHANG 2	311	39	a GONG DATUK BARAT	[illegible]	[illegible]
				b GONG DATUK TIMUR	[illegible]	[illegible]
				c DALAM PISANG	[illegible]	[illegible]
				d KEMUDU GONGKOK	[illegible]	[illegible]
	TOTAL	*311*	*39*	*TOTAL*	222	40
TOTAL		532	161		1050	164

Table 7: Descriptive statistics on the characteristic of household of the study population (n=325) according to the rural water systems.

	Characteristic	GFS	OHT	DC	AKSB	TOTAL	P VALUE
1.	Number of family members	5.56± 2.39^a	5.13± 2.56^a	5.80 ± 2.86^a	6.13 ± 2.89^a	5.60 ± 2.64^a	0.255*
2.	Number of water-tap	2.17± 0.65^a	2.94± 1.10^a	2.94 ± 1.41^a	5.15 ± 1.73^a	3.10 ± 1.47^a	<0.0001*
3.	Years of using	5.08± 1.53^a	5.90± 4.25^b	2.77 ± 3.22^b	15.2 ± 3.9^b	6.00 ± 8.00^b	<0.0001"
4.	Minimum pay	1.81± 0.40^a	5.85 ± 3.11^b	7.94 ± 8.30^b	7.14 ± 3.35^a	5.00 ± 7.00^b	<0.0001"
5.	Maximum pay	1.81± 0.40^a	8.48 ± 4.85^b	9.44 ± 9.95^b	9.00 ± 6.00^b	7.00 ± 12.00^b	<0.0001"

^{a} Mean ± Standard Deviation
^{b} Median ± Interquartile Range
" Kruskal - Wallis Test
* One- Way ANOVA

Table 8: Descriptive statistics of the water quality in terms of microbiological, physical and chemical results for each rural water systems

	Parameters	GFS	OHT	DC	AKSB	PERMISSABLE LEVEL BY MOH	p-value
1.	microbiology Number of E.Coli	208 ±662^b	0.00± 57.5^b	38 ± 218^b	0.00 ± 0.00^a	0	<0.0001*
2.	physical pH	6.73 ± 0.22^a	5.55± 1.86^a	5.41 ± 0.93^a	8.20 ± 0.89^a	6.5-9.0	<0.0001#
3.	colour	5.00 ± 0.00^a	5 ± 10^b	5.00 ± 0.00^a	0.00 ± 5.00^b	15 Hazen	<0.0001*
4.	turbidity	2.82 ± 4.31^b	1.83 ± 5.21^b	3.5 ± 7.63^b	1.21± 1.30^b	5 NTU	<0.0001*
5.	Free residual chlorine	0.00 ± 0.04^b	0.00 ± 0.03^b	0.02 ± 0.08^b	0.14 ± 0.72^b	>0.2mg/l	<0.0001*
6.	Temperature	26.95 ± 2.30^a	28.8 ± 1.00^a	29.5 ± 3.7^a	30.10 ± 2.20^a	–	<0.0001#
7.	Conductivity	0.03 ± 0.01^a	0.04 ± 0.06^b	0.06 ± 0.06^b	0.06 ± 0.02^a	100 mg/l	<0.0001*
8.	Total hardness	7.60 ± 5.95^b	9.50± 24.9^b	17.70± 19.80^b	15.80 ± 6.30^a	100 mg/l	<0.0001*

Table 8: continued

		GFS	OHT	DC	AKSB	PERMISSABLE LEVEL BY MOH	p-value
9.	chemical Total dissolved solid	0.01± 0.01^b	0.02± 0.03^b	0.03 ± 0.04^b	0.03± 0.00^a	500 mg/l	<0.0001*
10	ammonia	0.00± 0.05^b	0.00± 0.01^b	0.03 ± 0.29^b	0.00± 0.00^a	0.5 mg/l	<0.0001*
11	Iron	0.01± 0.02^b	0.01± 0.04^b	0.06 ± 0.13^b	0.00± 0.00^a	0.3 mg/l	<0.0001*
12	sulphate	0.55± 1.00^b	0.00 ± 1.20^b	5.00 ± 7.00^b	9.00 ± 1.00^a	400.0 mg/l	<0.0001*
13	phosphate	0.10± 0.12^b	0.08 ± 0.15^b	0.07 ± 0.12^b	0.08± 0.14^b	0.2 mg/l	0.071*
14	Nitrate	1.20± 0.40^a	1.40 ± 1.33^b	2.20 ± 2.10^b	1.3 ± 0.53^a	10.0 mg/l	<0.0001*

^{a} Mean ± Standard Deviation (SD)
^{b} Median ± Interquartile Range (IQR)
* Non-parametric Kruskal Wallis Test
# One-way ANOVA test

Table 9: Percentage of violation of the parameters tested after comparing with MOH drinking water standards.

	parameters	GFS N = 82	OHT N= 80	DC N= 84	AKSB N= 79	Total violation %	p-VALUE
1.	presence of E.Coli	100	40	69.9	3.8	54.3	<0.0001 ϕ
2.	pH	23.2 (low pH)	80 (low pH)	95.2 (low pH)	20.5 (high pH)	55.2	<0.0001 ϕ
3.	colour	no violation	7.5	2.4	no violation	2.5	0.541 ϕ
4.	turbidity	32.9	40.0	41.0	1.3	29.3	0.001 ϕ
5.	free residual chlorine	100	100	89.2	56.4	86.7	<0.0001 ϕ
6.	conductivity	no violation	no violation	no violation	no violation	no violation	-
7.	total hardness	no violation	no violation	no violation	no violation	no violation	-

ϕ Chi-square test

Table 9: continued

		GFS	OHT	DC	AKSB	TOTAL	p- value
8.	total dissolved solid	no violation	no violation	no violation	no violation	no violation	
9.	ammonia	no violation	no violation	14.5	no violation	3.7	0.988 ϕ
10	iron	no violation	no violation	14.5	no violation	3.7	0.988 ϕ
11	sulphate	no violation	no violation	no violation	no violation	no violation	
12	phosphate	15.9	18.8	15.7	16.7	16.7	0.945 ϕ
13	nitrate	no violation	no violation	no violation	no violation	no violation	

ϕ Chi square test

Figure 7: Percentage of microbiology violation (at least 1 E.coli colony presence) in 4 types of rural water systems.

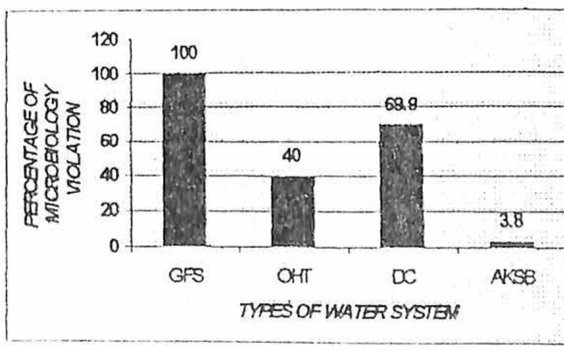


Figure 8: Percentage of p H violation in 4 types of water system.

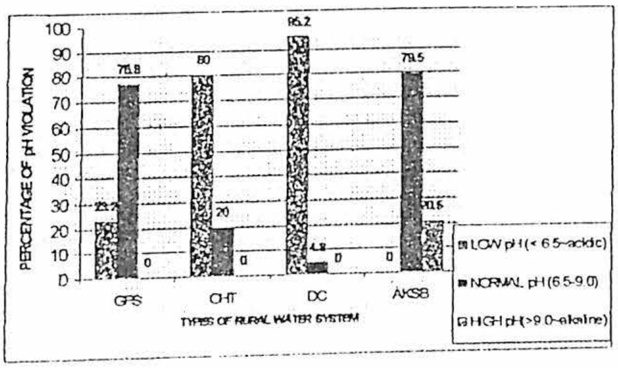


Figure 9: Percentage of turbidity violation (> 5 NTU) in 4 types of rural water system.

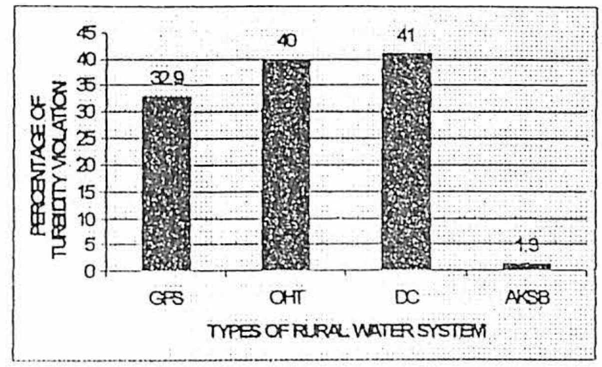


Figure 11: Percentage of free residual chlorine (< 0.2 mol/l) in 4 types of rural water system.

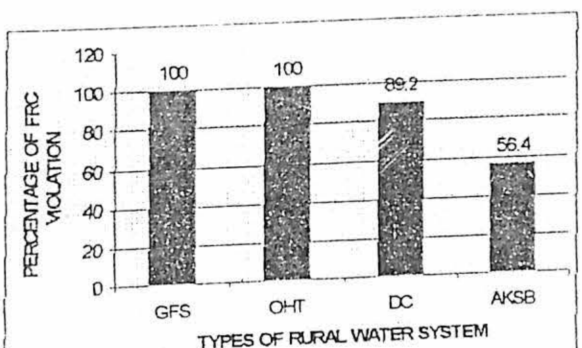


Table 8: Descriptive statistics on the consumer satisfaction.

Variables	%
1. Enough of water supply *(quantity)*	66.2
2. Satisfied with the water smell *(no smell)*	86.2
3. Satisfied with the water colour *(no colour)*	82.5
4. Satisfied with the water taste *(no taste)*	88.9
5. No health problem related to water supplies	99.1
6. To continue MOH water project	99.7
7. Practice of chlorination	39.7
8. Use alternatives water sources	34.5

Table 10: Percentage of consumer satisfaction on the quantity and quality of rural water system

SATISFIED WITH WATER	GFS n = 82	OHT n = 80	DC n = 84	AKSB n = 79	TOTAL n = 325	P - VALUE
Quantity (YES)	65.9	86.3	96.4	13.9	66.2	<0.0001♦
Colour (YES)	85.4	66.3	86.9	92.4	82.8	<0.0001 ♦
Taste (YES)	82.9	85.0	94.0	93.7	88.9	0.052 ♦
Odour (YES)	84.1	73.8	92.9	93.7	86.2	0.001 ♦
Others (YES)	95.1	91.3	94.0	97.5	94.5	0.421 ♦

♦ Chi square Test

Figure 13: Percentage of usage of alternative water sources.

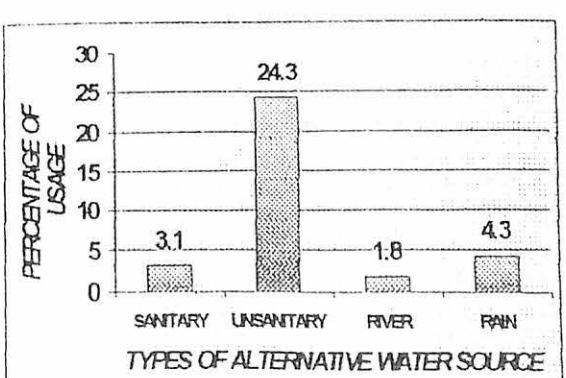


Figure 14: Percentage of houses with inadequate water supplies

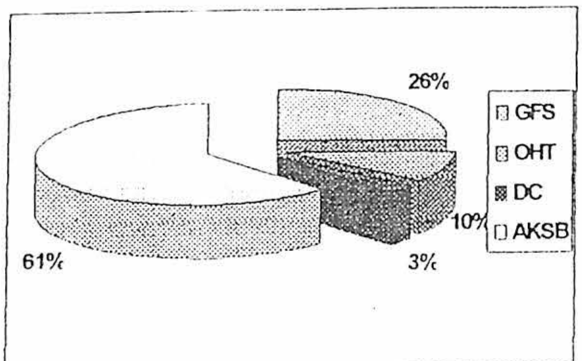


Figure 15: Percentage of total sanitary survey for risk of contamination

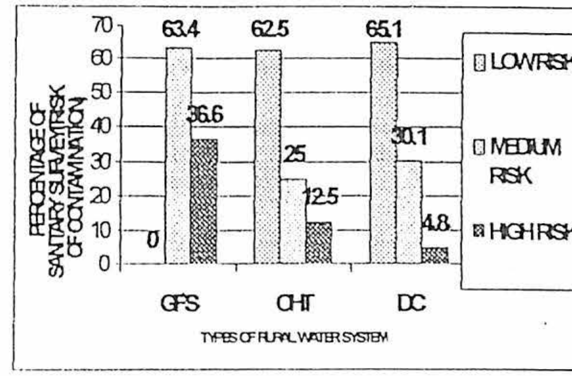


TABLE 11 : ASSESSMENT OF PRIORITY OF REMEDIAL ACTIONS BY RISK ANALYSIS

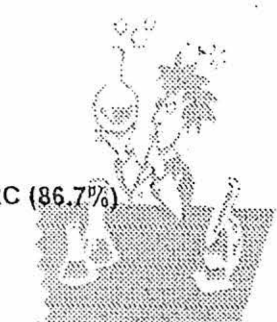
Sanitary inspection risk score

E. Coli Classification Count per 100 ml		0	1	2	3	4	5	6	7	8	≥9
>1000	E										
100-1000	D						GFS 63.4%				
10-100	C			DC 65.1%							
1-10	B										
0	A			OHT 62.5%							
		No action required	Low risk: Low action priority			Intermediate risk: Higher action priority			Very high risk: Urgent action		

Source: Guidelines for drinking-water quality: Surveillance and Control of Community Supplies WHO.1997

SUMMARY OF WATER ANALYSIS RESULTS.

- There's violation in:
- ~ *faecal coliform* (54.3%)
- ~ p H (55.2%)
- ~ colour (2.5%)
- ~ turbidity(29.3%)
- ~ free residual chlorin, FRC (86.7%)
- ~ phosphate (16.7%)
- ~ *ammonia* (3.7%)
- ~ iron (3.7%)
- No violation in temperature, total hardness,conductivity, Total dissolved *solid(TDS)*, *sulphate* & *nitrate*



DISCUSSION

- **5.1: The potability of 4 types of rural water system base on microbiological,physical and chemical parameters.**

- 5.1.1: Microbiological

  - *54.3% of total water samplings are contaminated with E.coli.*

  - GFS is the most unsafe water supply in which all water samples collected were contaminated. This system has no opportunity for disinfections at any where between the water source, distribution and the consumer house.

  - Detail study on GFS in Lesotho, South Africa by Kravitz (2000), *found 100% of the samples water are contaminated with coliform* whether GFS is unimproved, semi-improved or improved water source.

- ~ DC has a higher microbiological violation (69.9%) than OHT (40%). Dug wells are more exposed for contaminations because of the depth were less than 30 meters (usually around 6 to 9 meters), depends on the type of soil.
- ~ The safest water supply is the AKSB water connection because this is treated water but Sinclair *et al.* (2000), showed there have been a number of documented waterborne outbreaks in countries with a good water treatment practices.

- **5.1.2: Physical**
- The total of pH violation is 55.2% in which majority of it has low p H (<6.5) especially in OHT and DC. These 2 systems are raw water supply and not a treated water. There is no alum or lime added in the water supply. Majority of these water system are mixed with rain, which is more acidic type.
- Only 2.5% of the total samples have violation in colour with no violation at all in GFS and AKSB, which indicates that the water are very clear and colourless.
- 29.3% of the total samples have turbidity > 5 NTU, in which the problem occurs in the GFS, OHT and DC. This is because of the great demand from the consumers, there is no enough time for natural sedimentation process to take place.

- Free residual chlorine had total violation of 86.7%. All samples from GFS and OHT have violation in FRC.
- *89.2% of DC has violation of FRC although the health staff often* monitors this system. For DC, need to be chlorination at least once a month but this procedure failed .
- The consumers (60.3%) refused/ not keen for chlorination because:

  1. they believe that chlorine can kill their plantations and animals including "ayam serama", fish

  2. they disliked the smell and taste of chlorine
  3. they believed that chlorine can damaged the electric pump
  4. *sometimes the health staff asked the consumer to put the* chlorine by themselves but actually they used it for other purposes such as cleaning the drain and toilet.

5.1.3: Chemical
- 3.7% of violations occurs in ammonia and iron and these only in DC. DC is more exposed to underground contamination from *soil, fertilizer and other substances compare with OHT* because it is more shallower.
- Because of financial restraint, this study is unable to assess the *presence of other chemicals (such as aluminium), heavy metals* (such as lead, mercury, arsenic), total biocides, organochlorine pesticides (such as aldrin, DDT, lindane), herbicides (such as 2,4-D) and radioactivity (such as gross α and gross β).
- Heavy metals in the environment have become a major concern in public health.

5.2: Consumer satisfactions on the quantity and quality of rural water supplies by BAKAS project.
- 33.8% of the consumer complained getting inadequate water supply especially those who use water from AKSB. They have to get alternative water source to support their needs. These situations may expose them to water-borne diseases because majority of the sources they choose are unsanitary sources (30.4 %) and not monitored by MOH.
- 99.1% had no experience of any water related health problems or diseases . 99.7% agreed for continuing the BAKAS rural water projects because for them the quantity is more important than the water quality or potability. The water supply was also cheap that they can afford it .
- More than 80.0% of the consumer are satisfied with the colour, taste, odour and other quality parameter of the rural water supplies although majority of the water actually are not potable after tested with the standard instruments.

- 5.3: Sanitary survey for determination the risk of contamination of rural water system
- Sanitary survey is rather economical and intelligent approach to bacteriological testing where funding is limited (Llyod, 1991).
- GFS had the highest percentage of high risk (36.6%) of contamination and need urgent action. GFS is difficult for disinfections because this system have big operational area and produce plenty of water.
- AKSB water connection are the safest water to use for drinking (only 4.8% of high risk of contamination).
- OHT has more (12.5%) high risk for contamination than DC. But after assessment by risk analysis, OHT need low action priority and DC need higher action priority.

- Chi-square test showed that there is an association between risk of contamination and presence of E.coli or water potability ($\chi^2 = 64.00$, $p < 0.0001$). Chi-square test also showed that there is an association between risk of contamination and type of water system ($\chi^2 = 71.471$, $p<0.0001$).

- These sanitary score forms enables a hazard score to be assigned to the particular water supply based on the total number of hazard found; however, differential weighting may be necessary to allow for local conditions.

CONCLUSION & RECOMMENDATION

6.1: CONCLUSION

6.1.1:The potability of rural water supplies in Tanah Merah and Pasir Puteh are still not very satisfactory.

~The most important water quality parameter is the freedom from pathogenic microorganisms contained in faecal material.

6.1.2: Each type of rural water system has its own problems with the construction facilities, the maintenance, the consumer's perception, the quality and the quantity.

~The main problems for GFS, OHT and DC are the presence of E. coli, water p H less than 6.5, turbidity more than 5 NTU and low FRC with small percentage of violation in phosphate, iron and ammonia

- 6.1.3: Majority of the consumers is satisfied with the quality of rural water system although 66.2 % are still complaining of not enough water.

- 6.1.4: Regular sanitary inspections and water analyses are both important in maintaining safe drinking water supplies.
- ~sanitary survey score showed that GFS has more high risk for contamination.
- ~ There are significant associations between sanitary survey score with the water potability and types of rural water supplies.

6.2: RECOMMENDATIONS

- 6.2.1:This is only an exploratory study.
- Further studies are needed on each water system in detail and to correlate with incidence of diseases such as water-borne diseases,poisoning and other health problems.
- Knowledge attitude practice (KAP) study should be done on safe drinking water and good personal hygiene.
- This study can be extended for detail risk analysis and risk management of rural water supply.
- USM, Kelantan should have its own public/environmental health laboratory to monitor the drinking water quality and other environmental pollution.

- 6.2.2: Drinking water protection is a shared responsibility, involving water suppliers, local and state governments, and business individuals.

- Plans of action for improving access and quality of drinking water are:
- a. water policies, legislation and standards
- b. water quality surveillance and control
- c. increase in access to safe water and promotion of disinfection
- d. community participation and education
- e. establishment of a partnership
- f. prevent contamination from entering water source including proper management of waste water pesticides residual
- i. consumer must know the source of their drinking water and get involved in activity to protect it

6.2.3: This study recommended that good hygiene practices are the effective means of interrupting fecal-oral transmission and decreasing the interfamilial spread of diarrhea disease pathogens. Poor hygiene practices may be due to ignorance of sanitary principles, high cost, scarcity of clean water or distance from it.

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1 Oktober, 2002

Puan,

Pembentangan disertasi kepada kakitangan kesihatan di daerah yang berkenaan.

Perkara di atas adalah dirujuk.

2. Diharap pelajar berkenaan dapat membentangkan laporan disertasi kepada kakitangan yang banyak membantu dalam pengumpulan data (khasnya unit BAKAS) di Pejabat Kesihatan Tanah Merah dan Pejabat Kesihatan Pasir Puteh bagi mendapatkan maklumbalas.

3. Pembentangan ini juga untuk memenuhi kriteria dalam mengisi borang laporan akhir sesuatu disertasi yang dibiayai oleh geran jangka pendek USM.

4. Diharap pelajar dapat membentangkan perkara tersebut sebelum November 2002.

Sekian, harap maklum

Yang benar,

(Prof. Madya Dr. Zulkifli b. Ahmad)
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