THE EFFECTIVENESS OF CONTINUOUS BATCH COLUMN IN WASRA SYSTEM TO TREAT THE GROUNDWATER AT UNIVERSITY MALAYSIA PAHANG.

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ABSTRACT

Water is a chemical compound that is liquid at normal pressure and at room temperature. Water contains 70% of the earth's surface. Every life on this planet needs water to survive. Water can also exist in three forms such as ice (solid), water (liquid) and steam (gas). Based on Sumber Air Negara (MSAN) on 1982, monsoon season every year saturates with more than 990 billion m^3 of rainfall. Of this amount 6.5% or 64 billion m^3 remain in the groundwater. Due to the country's water resources are abundant, the total population increased from recent years. Increasing population causing pollution to the water sources. WASRA system is one of the systems that we use to treat the groundwater before supply clean water to the community. The aim of this study to determine the effectiveness of the batch column unit in WASRA Pre-treatment process to reduce groundwater contaminants and the removal of contaminants from groundwater through a continuous batch column in WASRA system. Sample from WASRA system before and after through the continuous Batch column will be tested based on eleven parameter referred to the "Standard Method for the Examination of Water and Wastewater" (21^{th} Edition) by American Public Health Associate (APHA, 2005). Analysis of data was performed by using a 1-way analysis-of-variance (1-way ANOVA). The significant ANOVA ($P<0.05$) studies shown the different in value of the monitored eleven parameters which indicates the data obtained is accurate. Water sample was taken from groundwater resources near to Mosque at University Malaysia Pahang. The result gained is relevant with the previous study on the same field. For the physical parameters, the removal efficiency for Turbidity and Total suspended solid is 79%, 79% respectively. The results for heavy metal test also showed the decreasing in its concentration. Percentage of removal for Zinc and iron is 71%, 67% respectively. Other parameters is hardness, conductivity, BOD_5, COD and manganese is 74%, 10%, 45%, 72%, 60% respectively. As a conclusion, the water is treated by Continuous Batch column in WASRA system is effectives to remove the groundwater contaminated at 95% and still acceptable to supply the clean water to the community.

ABSTRAK

Air merupakan sebatian kimia yang cair pada tekanan biasa pada suhu bilik. Air mengandungi 70% daripada permukaan bumi. Setiap kehidupan di planet ini memerlukan air untuk hidup. Air juga boleh wujud dalam tiga bentuk seperti ais (pepejal), air (cecair) dan wap (gas). Berdasarkan Sumber Air Negara (MSAN) pada tahun 1982, musim tengkujuh setiap tahun dengan lebih daripada 990 billion m^3 hujan. 65% daripada jumlah ini atau 64% billion m^3 meresap dalam tanah. Sumber air yang banyak menyebabkan jumlah penduduk meningkat dari tahun ke tahun kebelakangan ini. Peningkatan jumlah penduduk menyebabkan pencemaran kepada sumber – sumber air. Sistem Wasra adalah salah satu sistem yang digunakan untuk merawat air bawah tanah sebelum bekalan air bersih diagihkan kepada masyarakat. Tujuan kajian ini adalah untuk menentukkan keberkesanan proces pra-rawatan dalam Wasra untuk mengurangkan pencemaran air bawah tanah dan menyingkirkan pencemaran dari air bawah tanah melalui turus kelompok selanjar dalam sistem Wasra. Sampel air dari Wasra sistem sebelum dan selepas melalui turus kelompok selanjar akan dikaji berdasarkan kepada " Standard pemeriksaan air dan kumbahan air oleh American Public Health (APHA,2005). Analisis bermakna ANOVA ($P<0.05$) kajian menunjukkan perbezaan nilai dari sebelas parameter diperhatikan yang menunjukkan data yang diperolehi adalah tepat. Sampel air diambil dari sumber air bawah tanah berdekatan dengan masjid di Universiti Malaysia Pahang. Keputusan yang diperolehi adalah berkaitan dengan kajian sebelumnya di tempat yang sama. Kecekapan penyingkiran untuk kekeruhan dan pepejal terampai adalah 79% untuk kedua-dua parameter. Keputusan untuk logan berat juga menunjukkan penurunan dalam kepekatannya. Peratusan penyingkiran untuk zink dan iron adalah 71% dan 67%. Parameter lain adalah kekerasan, konduktiviti, BOD_5, COD, dan mangan adalah 74%, 10%, 45%, 72% dan 60%. Kesimpulannya, air yang dirawat dengan kumpulan berterusan dalam sistem Wasra adalah berkesan untuk menyingkirkan bahan tercemar sebanyak 95% dan sistem ini masih boleh diterima untuk membekalkan air bersih kepada masyarakat.

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LIST OF SYMBOLS

^{o}C	Degree Celsius
%	Percentage
mg/l	Milligram per liter
NTU	Nephelometric Turbidity Units

LIST OF ABBREVIATIONS

°C	Degree Celsius
%	Percentage
TSS	Total Suspended Solid
BOD_5	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
Mn	Manganese
Zn	Zinc
Fe	Iron
ANOVA	Analysis of Variance
UMP	University Malaysia Pahang
INWQ	Interim National Water Quality

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Water is a chemical compound that is liquid at normal pressure and at room temperature. Water contains 70% of the earth's surface. Every life on this planet needs water to survive. Water can also exist in three forms such as ice (solid), water (liquid) and steam (gas). In this layer of the earth's crust, water is most common substance found mainly in liquid from. However, there is also a large quantity of water present in the form of gas (vapour) in the atmosphere and in solid form (ice and snow). Water can be found in river, lakes, groundwater and wetland (Ramakrishnan, 1998)

Groundwater is an important direct source of water supply, especially in arid area where surface water is limited. Groundwater is filtered by flow, it generally requires little treatment for use as a water supply. Groundwater can be measure as subsurface storage of water with the limited evaporation depends on the surface water. However, if the water table is within the root zone of surface vegetation, groundwater can be lost by the evapotranspiration. The increasing and decreasing water table in the soil is depending on the average rainfall in the some areas.

Based on Sumber Air Negara (MSAN) on 1982, monsoon season every year saturates with more than 990 billion m^3 of rainfall. Of this amount 57% exists as the runoff of 566 billion m3, 36% or 360 billion m^3 is returned to the atmosphere by

evaporation and the remaining 6.5% or 64 billion m^3 remain in the groundwater. Recycled water into the atmosphere is not used, only surface runoff and groundwater that contributes to the nation's water supply by 630 billion m^3, although not all of this water can be used for the country's water needs. Only 10% (56 billion m^3) from 566 billion m^3 of surface runoff can be supply into a storage area or use directly. If added this to the amount of groundwater means of renewable water resources is 120 billion m^3 of water per year.

Due to the country's water resources are abundant, the total population increased from recent years. Increasing population causing pollution to the water source. According to World Health Organization (WHO), on 2012 , the quality of water, whether for daily used such as drinking, domestic used , food production or recreational purposes have an important impact on health. Water with poor quality can cause disease outbreaks and it can contribute to background rates of disease manifesting themselves on difference time scales. Initiatives to manage the safety of water do not only support public health, but often improve socioeconomic development and well- being as well. Improving access to safe drinking water can provide many advantages to the country. Safe drinking water is importance to the preservation of human healthy, especially to the children. Base on WHO, 1.6 million deaths of children per years can be attributed to unsafe water. Contamination can occur in surface water and groundwater

The contents in the groundwater are different with the water surface in-term on total dissolved solids in ground water is usually greater than surface water. There are many technology of the treatment process to treat groundwater. In most types of water treatment, address only the sources from groundwater contents. With drinking water or any water would use for industrial propose, treat the water to remove the material or suspended that causes the disease on human. Our focus is on the process that used in Water supply for rural area (WASRA) system.

WASRA system is one of the systems that we use to treat the groundwater before supply clean water to the community. Low maintenance cost is one of the advantages of this system compared to another system to treat the groundwater (Syukor, 2010)

1.2 PROBLEM STATEMENT

In a world globalization, the increasing development according to the increasing of the population growing in recent years causes lack of water in daily used. Uncontrolled development causes pollution in water flow like rivers, lakes, groundwater and wetland. Although Malaysia has a relatively positive environmental record, Malaysia faced problem of pollution of inland and marine water, groundwater and coastal erosion, along with water pollution and the problem of waste disposal due to the increasing development (WWF-Malaysia, 2001).

One responsibility of the U.S. Environmental Protection Agency (USEPA) is to protect all potential underground sources of drinking water. Under the general health protection, the federal government has the ultimate authority to accept or reject permits for innovative groundwater strategies based on their success or failure to meet the federal primary drinking water standard and secondary drinking water in table 1 at appendix.

In Germany the new Soil Protection Act and Ordinance describe quality goals for groundwater and define action, trigger and precautionary value for the soil-groundwater pathway (Federal Ministry for the Environmental (D), 1998,1999). This was not always the case. Until the 1970s, it was believed that groundwater was protected by natural filters. However, groundwater contamination can occur in various ways, from the ground surface, from the above from water table, or from below the water table (US Office of Water, 1990).

Table 1.2(a): Activities cause groundwater contamination.

GROUNDWATER SURFACE	infiltration of polluted surface water land disposal of waste stockpiles Dumps sewage sludge disposal	De-icing salt use & storage Animal feedlots Fertilizers & pesticides Accidental spills airborne source particulates
ABOVE WATER TABLE	Septic tanks, cesspools & privies Holding pond & lagoons Sanitary landfills waste disposal in excavations underground storage tank leaks	underground pipelines leaks artificial recharge sumps and dry well Graveyards
BELOW WATER TABLE	waste disposal in well Drainage well and canals Underground storage mines	Exploratory wells Abandoned Wells Water-supply wells Ground-water Withdrawal

Sources: (US Office of Water, 1990).

Warri Nigeria, is one of the most important oil producing in the Niger Delta of Nigeria. This company as a whole produces about 2 million barrels of oil per day. From this activity, there a some test to check the quality of groundwater. The result base on the physical-chemical and parameters quality from groundwater contamination in table 2 (Olobaniyi SB and Owoyemi, 2006).

Table 1.2(b): Parameter for groundwater contamination at Nigeria

Parameter	Range
pH	4.70-8.40
Total dissolved solid	21.90-300
Conductivity	43.51-601.00
Ca	17.64-94.00
Mg	1.93-39.85
Fe	0.06-0.15
HCO_3-	10.05-111.90
Cl^{-1}	26.35-128.00

Sources: (Olobaniyi SB and Owoyemi, 2006).

To achieve development that is based on a new technology, some people unrealised to protect the environment to reach their target. Therefore, many developed countries faced problem of pollution that led to the disaster such as landslides, flood, climate change and others. For example, China's state Environmental Protection Administration spent 21 billion Yuan cleaning it up during 10^{th} five years plan because of the water contamination (AsiaNews, 2007).

Besides that, demand for water has increase in recent years. This increase is due to the growing demand for the community and to the development. The increases of this demand also effect the water surface treatment to supply to the community. To overcome this problem is develop new sources of water. Groundwater is likely being one of the sources.

1.3 OBJECTIVE STUDY

The objective of this study are :

i) To determine the effectiveness of batch column unit in WASRA pre-treatment process to reduce groundwater contaminants.

ii) To determine the removal of contaminants from groundwater through continuous batch column in WASRA system.

1.4 SCOPE OF RESEARCH

University Malaysia Pahang (UMP) was the suitable location to conducted this researched in-term on groundwater level, near to laboratory and the climate Groundwater sources was been identified at near the UMP's mosque.

Focuses on this study is on the effectiveness of WASRA system on treat the groundwater and the process of each tank such as Aeration column, Multimedia Sand Filter and Advance Oxidation Media before and after supply to the community at UMP.

This study involves in-situ and ex-situ test to determining the parameters of the water before and after the treatment using WASRA system. Three parameters are selected for in-situ test which turbidity, salinity, PH and ten parameters are chosen for laboratory test such as hardness, total suspended solid , Biochemical Oxygen Demand BOD, COD, Mn , Zn, Fe, and conductivity .

1.5 SIGNIFICANT OF STUDY

By doing this study, it is really hope that this research will benefit most people especially in the UMP's community. It is also can save costs for the water supply from the water surface and solve the water shortage problem that occurs at UMP.

With the use of the batch column in WASRA technology, the groundwater contamination can remove and safe for the community uses without hesitating. This study will help to improve the groundwater contamination especially in water treatment. This system also can give the advantages to other people to treat their water from well that have been used since years ago without any proper treatment.

Another expectation from this study is given an economical reused compare to another method and will give a maximum quality to treat groundwater contamination. Increasing pollution of water resources, the uses of groundwater as alternative sources to get clean water, with are few treatments in WASRA system.

Technology of WASRA system, not only uses for UMP's community and Malaysia but also from other country can get benefit or advantage from this system. Improved technology and sharing the knowledge each other can produce a sense of care for the environment. It is also can raise the country on a world platform.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review is a summary and explanation of the current state of knowledge on a limited topic. The propose of literature review is to provide clues as to where future research is heading or recommend area on which to focus. The information could be obtained from journals, articles, book, report , other collection or internet web pages.

The topic that need to covered in this thesis is water cycle, formation of groundwater, quality of groundwater , treatment of water and summary.

2.2 HYDROLOGICAL CYCLE

Evaporation, evaporation and transpiration bring the water vapour to the atmosphere. The process by which the water is changed from liquid to a gas or vapour is called evaporation. Evaporation is the total water remove from an area by transpiration and by evaporation from soil and water resources. It is sometimes called consumptive use or total evaporation. Transpiration is the water given up by plants in the form of vapour through their leaves.

Open bodies such as ponds, lakes, river, seas, ocean etc., are the sources of the evaporation and they get water from precipitation. It can be said that evaporation, transpiration and precipitation occur in a cycle. It is popularly known as hydrologic cycle. The main features of the hydrologic cycle are shown in Figure 2.1 .

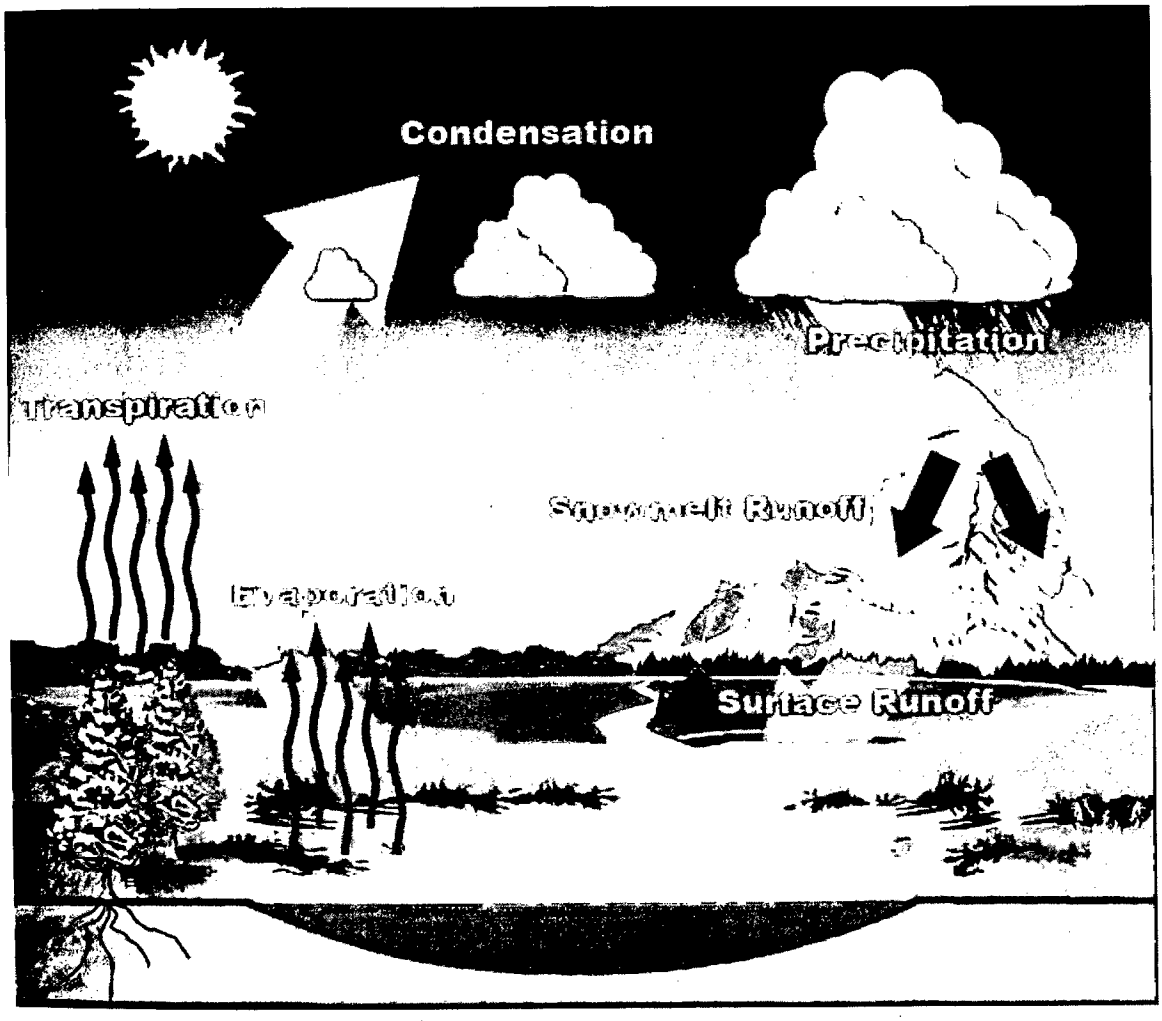

Figure 2.1: Schematic diagram of the hydrologic cycle

Sources: (The Hydrologic Cycle, 2010)

2.2.1 Runoff

Runoff occurs when there is excessive precipitation and the ground is saturated (cannot absorb any more water). Rivers and lakes are results of runoff. There is some evaporation from runoff into the atmosphere but for the most part water in rivers and lakes return to the oceans. If runoff water flows into the lake only (with no outlet for water to flow out of the lake), then evaporation is the only means for water to return to the atmosphere. With evaporation only pure water evaporated, and therefore any contaminates and salts are left behind. The result is the lake becomes salty as in the case of the Great Salt Lake in Utah or Dead Sea in Israel (National Weather Service, 2010).

2.2.2 Infiltration

The infiltration capacity of the soil helps the rain water to enter into soil. The process of water sinking into the soil is called infiltration. The 'filt' in the word infiltration is similar to the word 'filter' meaning 'to pass through'. The prefix 'in signifies that the process is one of passing into.

The surface of the earth can be compared to sieve. Imagine a sieve made of a very fine screen. If water is allowed to pass through the sieve made of a very fine screen (Ramakrishan, 1998).

2.2.3 Percolation

Chemistry and materials science, percolation the movement of fluid through porous material. Percolation component uses a storage routing technique to simulate flow through soil layers. The movement of water through the opening in rock or soil. Flow from a soil layer occur when soil content exceed field capacity. Water from the layer until the storage returns to field capacity. Percolation travel time through a layer is computed with the linear storage (Paul. Fernhoust & Cynthia. Kurtz, 1999).

2.3 FORMATION OF GROUNDWATER

2.3.1 Groundwater Concepts

An understanding of groundwater occurrence requires a study of the vertical distribution of water in subsurface geologic formations. The earth's crust is called the lithosphere. It is composed predominantly of rock, consisting of disintegrated rock materials such as granite and sandstone. The lithology of a action through the earth's crust reveals the kind of rocks that occur in a succession of layers of strata below the surface, that make up any part of the lithosphere.

The outer part of the earth's crust is usually porous to varying depths, at difference palces. This is the zone of rock fracture. The pores or openings in this part of the lithosphere may be partially or completely filled with water. In the surface strata, the openings are only partially filled with water. This strata is called the zone of aeration. The layer below this, where the openings are completely filled with water, is called the zone of saturation (Michael, 2008).

2.3.2 Aquifer

The zone of saturation may consist of permeable, impermeable and semi-permeable earth materials. An aquifer found between two impermeable layers is said to be confined. It is also called an artesian aquifer. Because of the presence of an upper confining layer, the water in the pores of a confined aquifer is not open to atmospheric pressure, but is at a greater pressure.

When a well is drilled into a confined aquifer, water rises in it to a level above the aquifer, depending on the pressure of the water in it. The elevation to which the water level rises is called the piezometric level. An imaginary surface representing the hydrostatic pressure in a confined aquifer is called the piezometric surface.

2.4 WATER QUALITY

Of all natural resources, water is unarguably the most essential and precious. Life began in water, and life is nurtured with water. There are organisms, such as anaerobes, which can survive without oxygen. But no organism can survive for any length of time with water. These organisms make water become contaminated if there are large amounts in the water. To monitored the total of organisms in water , there are some index as a guidelines to the researcher to determine the contaminated of water. This index was developed on the basis of water quality standards (Prati et al., 1971).

Table 2.4 Classification of water Quality for the development of Prati's

Parameter	Excellent	acceptable	Slightly polluted	polluted	Heavily polluted
PH	6.5 - 8.0	6.0 – 8.4	5.0 – 9.0	3.9 – 10.1	<3.9 - >10.1
DO (% Sat)	88 - 112	75– 125	50 – 150	20 – 200	<20 - >200
BOD_5 (ppm)	1.5	3.0	6.0	12.0	>12.0
COD (ppm)	10	20	40	80	>80
Permanganate (mg $l^{-1}O_2$) (Kubel test)	2.5	5.0	10.0	20.0	>20.0
Suspended solid (ppm)	20	40	100	278	>278
NH_3 (ppm)	0.1	0.3	0.9	2.7	>2.7
NO_3 (ppm)	4	12	36	108	>108
Cl (ppm)	50	150	300	620	>620
Iron (ppm)	0.1	0.3	0.9	2.7	>2.7
Manganese (ppm)	0.05	0.17	0.5	1.0	>1.0
ABS (ppm)	0.09	1.0	3.5	8.5	>8.5
CCE (ppm)	1.0	2.0	4.0	8.0	>8.0

Sources: Index Prati et al., 1971.

2.5 DRINKING WATER QUALITY

Drinking water quality is the describe of the quality parameters set for drinking water. Every human on this planet need drinking water to survive and that water may contain the compound that can make the water become contaminated. Many developed countries has a specific standard to applied in their country such as Europe, US and China. For those countries without a legislative for drinking standard, the World Health Organisation publishes guidelines of the standard that should be achieved.

Table 2.5: WHO drinking water guideline

Test parameter	Units	WHO standard
PH	-	6.5-8.5
magnesium	Mg/l	-
calcium	Mg/l	-
Sulphate	Mg/l	250
Chloride	Mg/l	250
Silica as SiO2	Mg/l	-
Iron	Mg/l	0.3
Manganese	Mg/l	0.1-0.5
sodium	Mg/l	-
Hardness as CaCO3	Mg/l	-
turbidity	Mg/l	-
Bicarbonate	Mg/l	-
Nitrate as N	Mg/l	50
cadmium	Mg/l	< 0.003
Lead	Mg/l	< 0.01
Potassium	Mg/l	-
Total Dissolved Solid	Mg/l	1000
Dissolved oxygen	Mg/l	-
Ammonia as N	Mg/l	-
Total alkalinity as CaCO3	Mg/l	-

Sources : WHO, 2012