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STRATEGIES IN MITIGATING ARSENIC CONTENT IN RIVER WATER

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Abstract

Higher arsenic concentrations in Sg Rui and Sg Perak have become a major concern for Gerik residents. The river water has always been the source of drinking water and also a source of income for the local community. But now it is suspected that tin mining activities on the upper stream causes arsenic problem at concentrations higher than the safe limit set by the Department of Environment and Ministry of Health and has become an emerging concern for water supply and health related issues. The purpose of this paper is to assess the water quality status of both locations above where complaints have been received. Comparative evaluation of treatments such as coagulation, adsorption by activated carbon, degradation by enzymes, removal by magnetized nanoparticles and filtration by sand media has been done. Detection of arsenic contents in water treatment analysis was determined by using inductively coupled plasma optical emission spectroscopy (ICP-OES) based on the standard method APHA 3120B. The test shows that the mean level of arsenic contents in the samples is more than 0.25 mg/L which is higher than 0.01 mg/L permitted by the standards. The comparison revealed that sand-filtration has better removal efficiency for arsenic removal from the mean levels of 0.35 mg/L up to 99.9% of reduction. This simple and affordable process of removal can be used to accommodate clean water for the public. A larger scale field test is currently underway.

Keyword: arsenic, water quality, water treatment, drinking water, sand-filtration

Introduction

Water pollution issues at Sg. Rui has caught the national attention with urgent action taken up by the Minerals and Geoscience Department (JMG) and the National Water Service Commission (SPAN) to identify the source of the arsenic contamination. Sg. Rui as a raw water supply source for the Kg Ayer Ganda water treatment plant is capable of supplying water to 1,000 villagers at a capacity of 0.68 million liters per day. Fluctuated in river raw water quality of Sg. Rui such as turbidity, pH values and the presence of heavy metals especially arsenic in may be due to mining activities (Affandi and Ishak, 2018) besides other sources of contamination such as agricultural activities, logging and other anthropogenic activities occurs around the area. In December 2019, higher arsenic concentrations in Sg Rui and Sg Perak have become a major concern in for Gerik community (The Star Online, 2019). We measured the arsenic contents at average of 0.25 mg/L which is higher than 0.01 mg/L permitted by standards. The purpose of this research is to assess the water quality status of two locations where complaints have been received and undertake suitable treatment to be adopted in mitigating its arsenic content to the point where it is safe to be use.

Material and methods

The sampling sites are at Dataran Loma, Sg. Rui and Kg. Ayer Ganda, Sg. Perak (Figure 1). Both locations designated P1 (5° 27' 33.7212" N 101° 10' 32.3652" E) and P2 (5° 19' 15.618" N 101° 9' 8.2368" E) respectively were selected on the recommendation of the Perak JMG, both of which were the highest receiving local community complaints with issues such as the occurrence of dead river fishes and smelly river water. We undertake in-situ monitoring for Dissolved Oxygen (DO), Turbidity and pH as well as water samples will be collected and taken directly to the Water Quality Laboratory, NAHRIM for water quality analysis. A total of over (>) 50 liters of water samples will be sampled in different types of bottles and sizes.

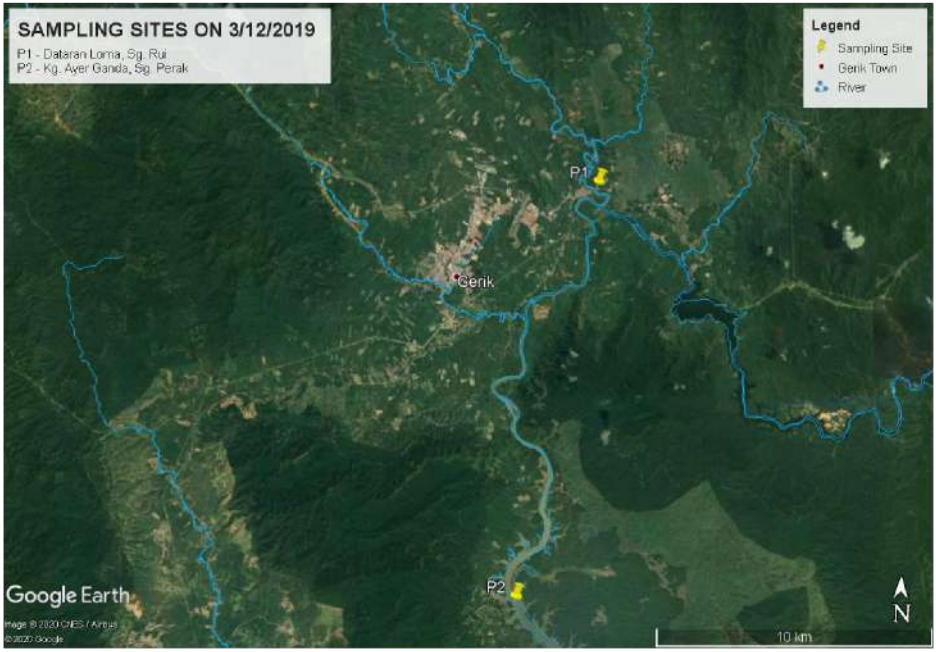


Figure 1. Sampling sites for P1 and P2.

The NAHRIM developed treatment applied for mitigating the arsenic and others pollution contents as follow. First, the bioflocculants used are from Volcanic Ash (VA), Rice husk (S), Moringa (M) and commercial coagulant (MP) as well as alum or Aluminium Sulphate was used in in reducing the turbidity of collected water samples, turbidity reading were taken after 5, 10, 15, 20, 25 min of treatment to determine the percentage of decrease in turbidity using Jar Test test analysis. Second, arsenic removal using activated carbon (DM) was performed with 1g of DM was mixed with 500 mL of P1 water sample and stirred at room temperature for 100 rpm for an hour, the water samples were then filtered and analyzed for heavy metal content after treatment (Figure 2) using ICP-OES (APHA, 2017).

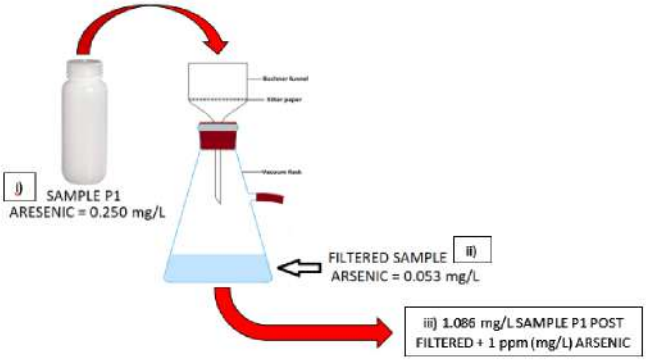


Figure 2. FILTRATION PROCESS - Arsenic content of sample P1, i) 0.250 mg / L of homogeneous sample; ii) 0.053 mg / L after filtering with filter paper; iii) 1.086 mg / L sample was filtered and supplemented with 1ppm Arsenic

The third treatment application developed by NAHRIM is by sand-filtration steps. P1 water samples were left for the precipitation process to occur naturally. Comparison of arsenic content was performed for precipitated sediment, water solution as well as homogenized water samples. Subsequently the water samples (homogeny and after precipitation) were used in sand filtration systems for the treatment of heavy metals. Two filtration systems are used: sand filtration and sand filtration with commercial activated carbon (CAC). Arsenic content of the water sample after the treatment was also taken for comparison.

Results

The in-situ parameter analysis (Table 1 and 2) included pH, temperature, dissolved oxygen, turbidity, suspended solids, and conductivity show high significance differences between two sites at $p<0.05$.

Table 1. in-situ parameter analysis for P1.

pH	ORP (mV)	Turbidity (NTU)	Total Suspended Solids (mg/L)	RDO (mg/L)	RDO (%Sat)	Actual Conductivity (ÂµS/cm)	Temperature (°C)
7.2	309	54.98	52.23	8.22	105.23	136.87	27.63

Table 2. in-situ parameter analysis for P2.

pH	ORP (mV)	Turbidity (NTU)	Total Suspended Solids (mg/L)	RDO (mg/L)	RDO (%Sat)	Actual Conductivity (ÂµS/cm)	Temperature (°C)
6.3	274	39.34	37.37	5.89	77.52	59.84	29.19

**ORP: Oxidation-Reduction Potential, RDO: Rapid Dissolved Oxygen, in-situ: On-Site*
**('UNIT') is the unit of each respective parameter*

Generally, the water quality index (WQI) level for P1 is at Class II while for P2 at Class III (Table 3 and 4). Both values are at a moderate rate, only slightly contaminated recorded at the populated area of Kg. Ayer Ganda (P2). Turbidity trend reading also recorded at both sampling sites (Figure 3 and 4). Readings such as PO4, NO3, NO2, Oil and Grease, Total Coliform and E. coli are also at normal levels. In addition, we found that relatively high arsenic readings above 0.01 mg / L (the rate allowed by national standards, DOE, 2019) and others heavy metals readings such as lead, Cadmium, Manganese and Mercury are well above normal levels, and this suspected that the high readings are due to mining activity at upstream (Orji et al., 2014).

Table 3. Water quality index (WQI) level for P1.

pH	COD, mg/L	BOD 5, mg/L	DO (%Sat)	Ammoniacal-Nitrogen (NH3-N)	Total Suspended Solids (mg/L)	WQI	STATUS	CLASS
7.3	4.6	<1	8.22	0.08	69	81.5	Clean	II

Table 4. Water quality index (WQI) level for P2.

pH	COD mg/L	BOD 5 mg/L	DO (%Sat)	Ammoniacal-Nitrogen (NH3-N)	Total Suspended Solids (mg/L)	WQI	STATUS	CLASS
6.4	4.4	2.3	5.89	0.16	29	76.0	Slightly Polluted	III

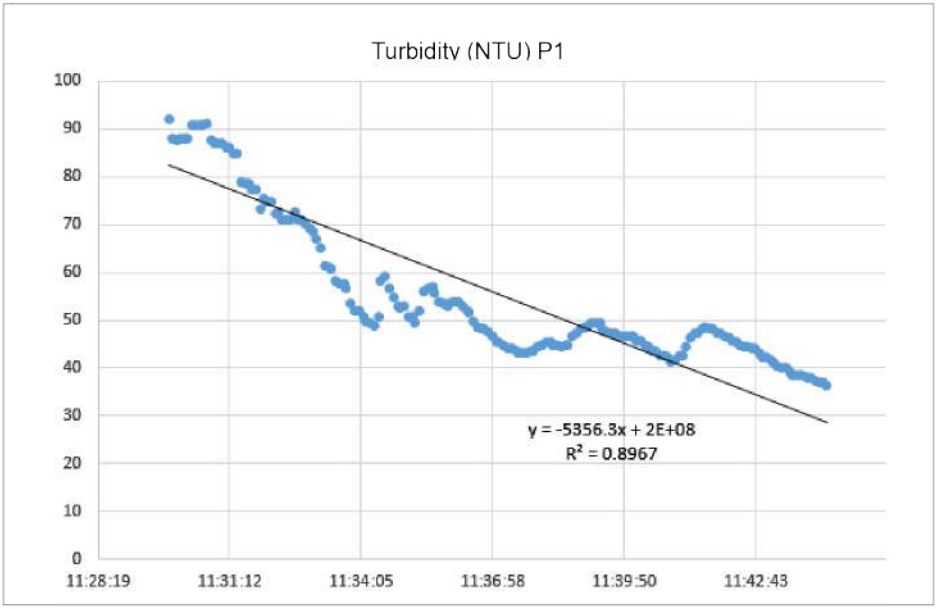


Figure 3. Downward trend for turbidity (NTU) level for P1 on 3/12/2019.

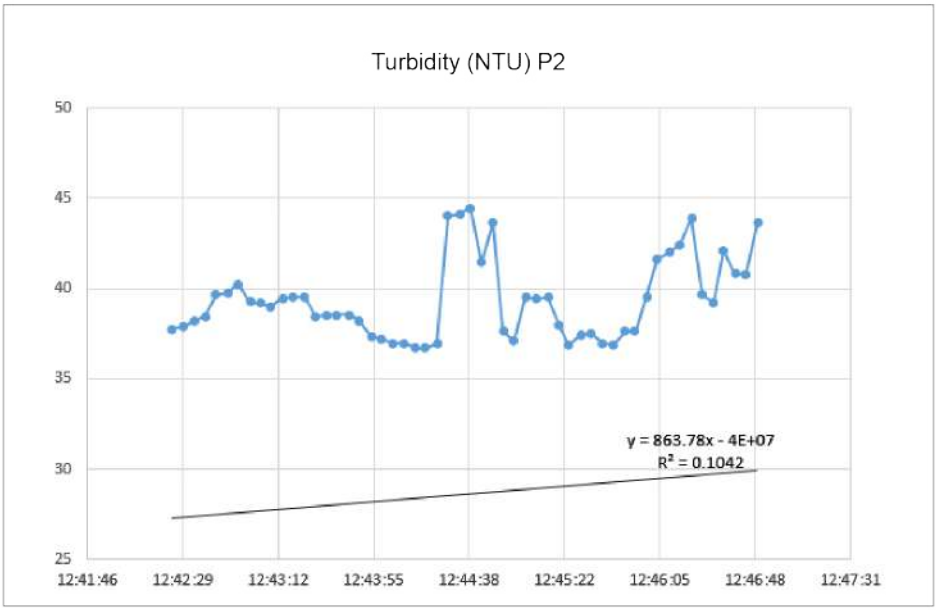


Figure 4. Upward trend for turbidity (NTU) level for P2 on 3/12/2019.

Discussion

The proposed water treatment process for mitigating arsenic content in the sampled river water involves two steps which are coagulation using bioflocculant which will clog and reduce the turbidity in water and uses of others alternative treatment which treats soluble chemicals such as arsenic. Analysis of treated water undergoing both processes was reported to have a reduction in arsenic content (up to 99%) as well as others contamination indicator.

Table 5. Coagulation treatment for turbidity reduction using bioflocculant

COAGULANT	Time (Minute)						Reduction
	0	5	10	15	20	25	%
CONTROL	97.9	57.6	56.4	33.2	31.5	30.5	68.85
MP 0.125	97.9	7.5	6.0	2.7	2.6	2.5	97.45
VA 0.125	119.0	11.8	5.3	3.0	2.9	2.8	97.65
S 10	234.0	35.7	19.7	14.5	13.8	8.5	96.36
M 0.1	145.0	29.3	19.9	17.1	8.7	8.4	94.21
A 0.125	106.0	16.9	9.2	3.4	3.2	2.9	97.26

**MP: commercial coagulant; VA: volcanic ash; S: bioflocculant from rice husk; M: bioflocculant from moringa; A: alum or Aluminium sulphate*

Table 6. Coagulation treatment for heavy metals including arsenic reduction using bioflocculant

ELEMENT/ COAGULANT	METALS REDUCTION RESULT (mg/L)					
	BEFORE (CONTROL)	MP 0.125	VA 0.125	S 10	M 0.1	A 0.125
Pb	0.025	0.010	0.010	0.014	0.014	0.007
Zn	0.172	0.170	0.172	0.468	0.496	0.135
Al	2.262	3.329	1.874	0.540	0.496	9.214
Al	2.369	3.457	1.931	0.524	0.486	10.030
Ni	0.030	0.028	0.031	0.029	0.031	0.027
Cr	0.008	0.006	0.006	0.009	0.007	0.005
Fe	4.698	1.998	2.756	1.979	1.826	1.848
B	0.027	0.034	0.031	0.051	0.040	0.034
Cu	0.161	0.153	1.143	0.152	0.154	0.158
Se	0.008	0.005	0.006	0.010	0.003	0.004
Ag	0.007	0.007	0.007	0.008	0.008	0.007
Sn	-0.009	-0.012	-0.009	-0.009	-0.009	-0.009
Ba	0.021	0.013	0.017	0.012	0.011	0.010
Mn	0.321	0.349	0.422	0.457	0.358	0.332

Cd	0.009	0.009	0.008	0.009	0.009	0.009
As	0.227	0.065	0.063	0.086	0.070	0.059
Mg	1.517	1.807	1.846	18.440	2.118	1.506
Na	1.420	11.000	1.729	1.594	1.685	1.557
Ca	13.470	30.670	16.040	14.690	14.570	13.200

**MP: commercial coagulant; VA: volcanic ash; S: bioflocculant from rice husk; M: bioflocculant from moringa; A: alum or Aluminium sulphate*

Table 7. Absorption treatment for heavy metals including arsenic reduction using activated carbon.

ACTIVATED CARBON/ ELEMENT	WATER TREATMENT HEAVY METALS REDUCTION RESULT (mg/L)				
	BEFORE (CONTROL)	SPIKED SAMPLE (as 1 mg/L)	DM	CAC	MP
Pb	0.033	0.032	0.015	0.035	0.007
Zn	0.084	0.080	91.620	0.119	0.112
Al (L)	0.423	0.427	0.430	0.439	2.341
Al (H)	0.421	0.415	0.432	0.442	2.342
Ni	0.031	0.031	0.028	0.031	0.023
Cr	0.006	0.006	0.006	0.005	0.006
Fe	1.573	1.587	0.974	1.489	0.205
B	0.042	0.041	0.061	0.044	0.044
Cu	0.118	0.113	0.065	0.122	0.016
Se	0.005	0.007	0.004	0.005	-0.004
Ag	0.008	0.007	0.007	0.007	0.010
Sn	-0.008	-0.012	-0.008	-0.010	-0.019
Ba	0.013	0.013	0.020	0.015	0.009
Mn	0.390	0.393	0.399	0.390	0.299
Cd	0.008	0.008	0.011	0.008	0.008
As	0.053	1.086	1.031 **(5.06%)**	1.106 **(NA)**	0.128 **(88%)**
Mg	1.809	1.830	5.243	2.173	2.460
Na	1.723	1.745	1.975	3.616	-
Ca	16.710	16.770	18.260	17.360	280.500

**Spiked Arsenic 1ppm (1mg/L)*
**DM – activated carbon*
**CAC – commercial activated carbon*

ELEMENT/ PROCESS	HEAVY METALS REDUCTION RESULT (mg/L)								
	BT1	AT1	BT2	AT2	BT3/AC	AT3/AC	BT4	AT4	SLUDGE
Pb	0.163	-0.003	0.038	-0.002	0.055	-0.009	0.007	-0.005	0.522
Zn	0.199	0.111	0.139	0.128	0.127	0.072	0.127	0.120	0.253
Al (L)	3.826	0.727	2.633	0.218	3.060	0.063	0.457	0.184	42.610
Al(H)	3.593	0.684	2.498	0.213	3.139	0.068	0.465	0.183	39.370
Ni	0.024	0.010	0.022	0.015	0.023	0.011	0.021	0.015	0.131
Cr	0.005	0.001	0.004	0.000	0.005	-0.001	0.006	0.000	0.073
Fe	5.674	0.713	5.086	0.329	5.199	0.083	1.743	0.422	84.020
B	0.016	0.003	-0.014	0.003	-0.013	-0.001	-0.005	0.002	-0.346
Cu	0.311	0.084	0.210	0.075	0.198	0.029	0.180	0.066	0.765
Se	0.000	-0.003	0.004	0.012	0.010	0.000	0.003	0.006	-0.030
Ag	0.009	-0.002	-0.004	-0.002	-0.003	-0.003	-0.003	-0.001	0.059
Sn	0.020	-0.010	0.003	-0.009	0.011	-0.009	0.001	-0.008	0.103
Ba	0.051	0.027	0.047	0.032	0.049	0.029	0.033	0.032	0.336
Mn	0.390	0.263	0.378	0.313	0.410	0.303	0.399	0.329	0.721
Cd	0.033	-0.001	-0.001	-0.001	-0.001	-0.003	-0.002	0.000	0.020
As	**0.334**	**0.020**	**0.324**	**0.005**	**0.298**	**0.000**	**0.043**	**0.006**	**6.791**
Mg	1.658	2.977	1.655	2.548	1.825	2.634	1.672	2.416	4.065
Na	1.502	1.613	1.423	1.540	1.522	3.412	1.508	1.584	1.737
Ca	14.090	113.10	13.550	95.050	14.530	88.570	14.750	90.180	15.640

**BT1 & BT2 – before sand filtration; *AT1 & AT2 – after sand filtration; *BT3 – before sand filtration + commercial activated carbon (CAC); *AT3 – after sand filtration + commercial activated carbon (CAC) *BT4 – before sand filtration using sedimented water sampel; *AT4 – after sand filtration using sedimented water sampel; *SLUDGE – sedimented sampel from BT4*

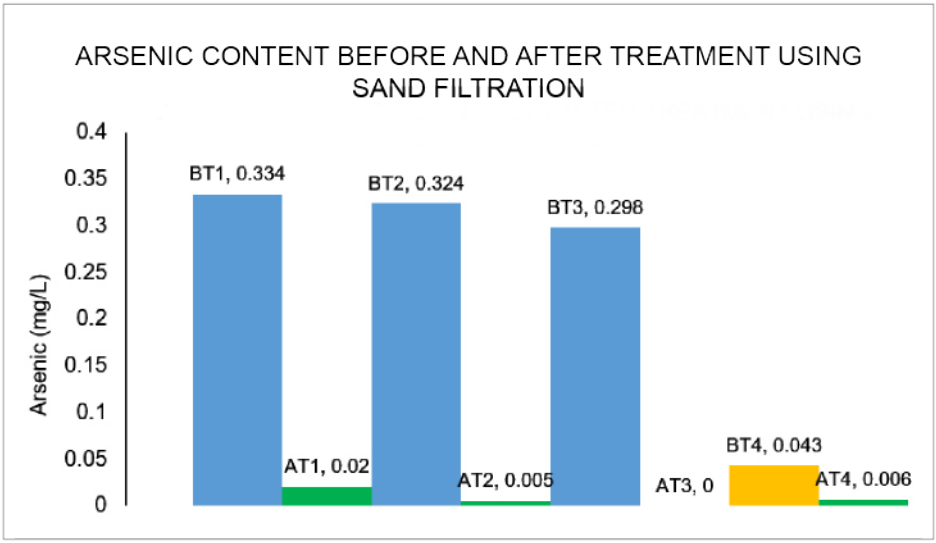


Figure 5. Comparison of arsenic content before and after treatment using sand filtration. BT1, BT2: before sand filtration treatment; AT1 & AT2 - after sand filtration treatment; BT3 - before sand filtration + activated carbon (CAC) treatment; AT3 - after sand filtration + activated carbon (CAC) treatment; BT4 - before sand filtration treatment (sedimented samples); AT4 - after sand filtration (sedimented samples).

From the analysis above, the sand filtration with commercial activated carbon (CAC) system was able to remove 100% arsenic using a homogeneous water sample compared to the sand filtration system alone to remove 87% of arsenic content in a homogeneous water sample and 86% for aqueous sample.

Conclusions

Test results for commercial coagulant has been shown to be able to reduce turbidity by ~ 90% and also arsenic content by ~ 67%. From these comparisons, it can be concluded that the sand filtration system and activated carbon can efficiently remove Arsenic pollutants effectively by ~100%. We recommended the treatment method using sand media filtering system as it is easier to apply and more cost effective than the other methods used. The following is a comparison of Arsenic content reduction treatments for each product used (Table 9).

TREATMENT MEDIA AND METHOD	BEFORE CONTROL (mg/L)	AFTER TREATMENT (mg/L)	Reduction (%)	Treatment Time (Hour)
M	0.227	0.07	71	
S		0.086	62	
VA		0.065	69	
DM	1.086(*spike 1ppm)	1.031	5.06	1
CAC		1.106	0	1
Sand Filtraton	0.3241	0.005	98	
Sand Filtration + Commercial Activated Carbon	0.298	0	100	-
MP	0.2271	0.074	67	

Acknowledgements

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DESIGN OF NAHRIM COASTAL DEFENSE AND ELECTRIC GENERATOR (N-CODE) AT PANTAI KERACHUT, PULAU PINANG

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Abstract

Scientists are increasingly seeking electricity from the environment. Today, water is among the most natural resource elements compared to forest elements. Water research is growing and utilizing from rainwater, surface water to seawater. Characteristics of hydraulic sources of water such as currents, waves, thermal water, gravity fall rain, wastewater had been considered as one of the renewable sources of energy. However, rivers and oceans are the closest source of hydraulic energy to coastal activities and coastal activities. Kerachut Beach Turtle Conservation Center supervised by the Penang Fisheries Department still has no electricity supply from Tenaga Nasional Berhad Company. Not far from commercial areas, settlements and maintenance workshops caused electricity to be supplied from the portable diesel generator on a daily basis. The significant use of its electricity supply is for the purpose of refrigerating the food supply of turtles and some basic office needs. The objective of the N-CODE study in Kerachut Beach 2019 is to test the performance of N-CODE design in reference to the hydrodynamic Kerachut Coast. In the N-CODE study in Kerachut Beach 2019, there are two (2) basic parameters studied namely the change in performance of N-CODE in generating electricity and changing wave conditions. Kerachut Beach is part of the Penang National Park, making it one of the most popular destinations for domestic and foreign visitors. The N-CODE study in Kerachut Beach 2019 found that there are five (6) factors that influence the performance of N-CODE, namely hydrodynamic factors such as waves, currents, winds, turbulence and weather. Design factors such as anchor tension level, N-CODE cable and magnetic movement efficiency in low water conditions. Further studies are suggested based on the latest findings found during the N-CODE study in Kerachut Beach from the factors of the magnitude of the waves, currents, winds, turbulence and weather.

Keywords: Hydraulic, Renewable, Hydrodynamic, Magnetic Movement, Waves.

Introduction

Much of conventional design for renewable energy generator was created from natural resources such as rivers, biogas and open channel. Energy consumption will be continue increasing over the years ahead due to energy cost, whereas lifestyle had changes the energy landscape. Expert around the world had begun to seek potential renewable energy sources from natural resources as found Alla et al. (2014). According to United Nation, on April 2010, about 1.5 billion have no access to electricity. WHO estimates that more than 1.45 million people die prematurely each year from indoor air pollution caused by burning solid fuels, traditionally without using electric cooking burner (Askari et al., 2015; Alain et al., 2002; Adrien et al., 2015; B Drew et al., 2009; Dina et al., 2013).

Nowadays, energy harvesting from the open water had been taken place worldwide in commercial scale. Open water contains potential hydraulic energy via its wave with wind and current sources. Studies had found ocean wave and current could be dissipated and converted into electric generation (Eugen, 2014). Ocean tide is a natural resource and it create a natural gravitational effect in a day. Tides occur twice in 24 hours at different location caused by the gravitational effect of the

moon (Eduard et al.,2016).

Worldwide designs of open water generator had produce electricity from up to large scale electricity distribution directly from open waters. Currently, there are commercial system that had been used in the world (Guilherme et al., 2014). The tidal change in the range of 10.8meters had generated the system about 16MW and distributing 30 million kWh of electricity per year at Fundy Bay, Canada (Jenny H & Peter O., 2011; Juanhua et al.,2016; James et al. 2013). Surrounded by 4,675kilometers coastline with islands, Malaysia had advantage for the continuous research and development of the open water generator.

Material and methods

In this Phase 5/2019, Pantai Kerachut, Pulau Pinang had been decided as the first location under Straits of Malacca for N-CODE site testing. Research had collaborated with Department of Fishery, Pulau Pinang. Department of Forestry, Pulau Pinang (DOFPP) and the State Government of Penang as to meet research objective. The DOFPP had agreed for NAHRIM to install power distribution from the power harvesting from N-CODE which deployed 100 meters to the Pantai Kerachut beach. Power cables had been laid out 70 meters submerged underwater and under ground towards the DOFPP office of Turtle Conservation and Information Centre, Pantai Kerachut (TCIC) as schematic in Figure 1. Theory/calculation

A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis.

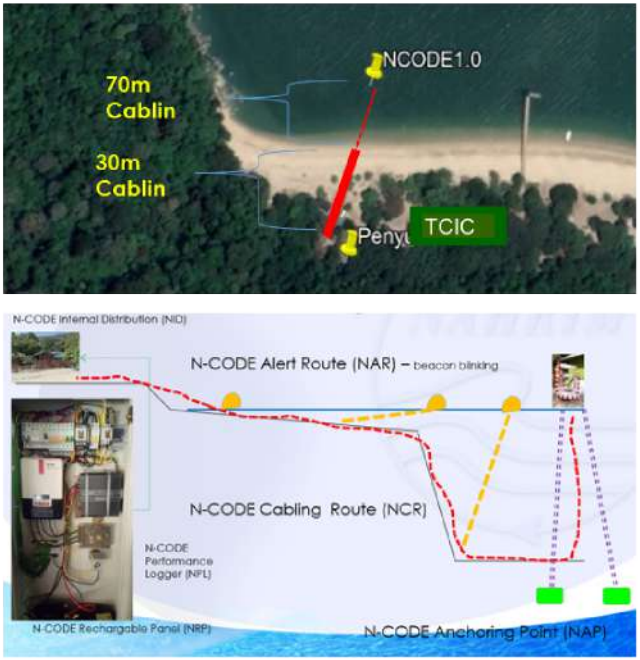
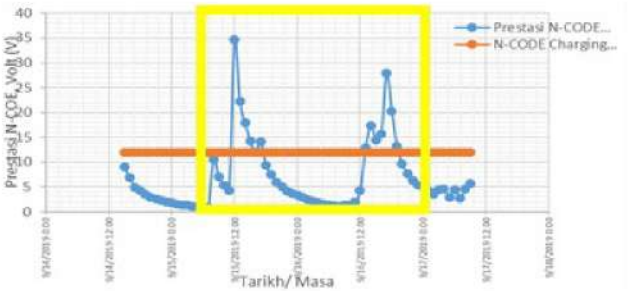


Figure 1. N-CODE deployment: (a) cabling from deployment coordinate of 5°27'0.25"N 100°10'54.67"E to the Turtle Conservation and Information Centre, Pantai Kerachut (TCIC); and (b) schematic of N-CODE installation.

Results

Phase 4/2018 had given positive expectation of N-CODE performance tested at South China Sea deployment. In this Phase 5/2019, N-CODE had also given positive result proofing that the concept could be apply for any location under Straits of Malacca. In Figure 2, N-CODE could possible generated at maximum 35 Volt at 0.35 meter of wave height.

(a)



(b)

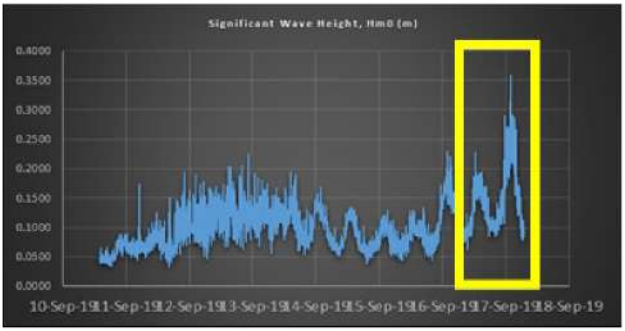


Figure 2. N-CODE performance compare to wave magnitude during site testing.

However, N-CODE could not generate power more than 12 Volt for charging battery during low wave height for few hours. During the site-test, anemometer shows that potential result for N-CODE upgradation. As hydrodynamic influencing N-CODE performance, N-CODE could possible charging battery and distributing power for the TCIC office at improvement of structural improvement.

From the study, Pantai Kerachut found as a potential site for long terms deployment. Figure 3 shows the wave data processing using MIKE21 indicating overall wave model around Pulau Pinang. The dominant wave direction is at 210 degrees.

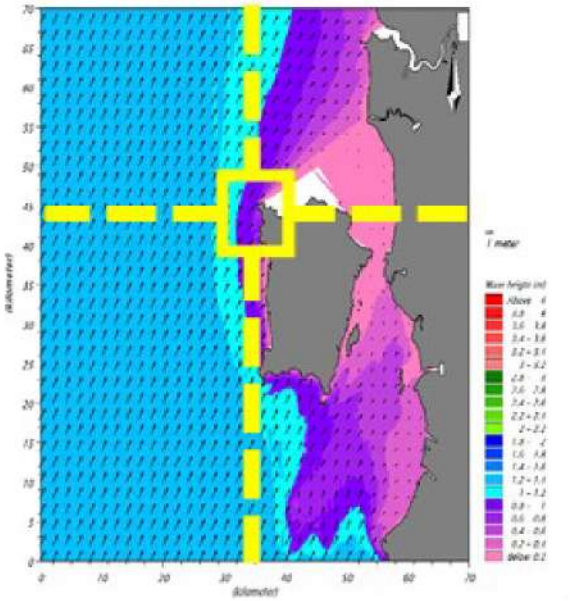


Figure 3. Overall wave model around pulau pinang influencing N-CODE performance and potential exact deployment point.

Material and methods

Previously from Phase 1/2015 to Phase 4/2018, N-CODE had been laboratory tested and some site tested. Instrumentation was limited to measure hydrodynamic influencing N-CODE performance during both laboratory and site test. During the N-CODE site testing for Phase 5/2019, N-CODE could have generated energy at high tide and high wave. However, some upgradation works for N-CODE shall be implemented for it operational at very low hydrodynamic readings. Further study shall be considering a certain hydrodynamic parameter for a year data collection. Satellite data transfer for hydrodynamic database is recommended during the study for real time data collection include weather station, wind magnitude and tide effects. Overall floatable structure will be recommended to be redesign to increase N-CODE dissipation rate

Conclusions

In this study, it shows that any open water design could be further study for efficiency improvement. The N-CODE testing at Pantai Kerachut had discovered that open water in the Straits of Malacca could possible dissipated electricity. The main influencing of N-CODE performance at Pantai Kerachut is the hydrodynamic factors. Further study in a long term data collection shall be execute in order to correlate selective hydrodynamic parameter related to N-CODE such as Wind Speed, Rain, Temperature, Wave, Tide. Computer Fluid Dynamic shall be carried out for running numerical testing for N-CODE design upgradation. The upgradation shall should not be oversized and undersized and considering its floatable structure design,

the electromagnet efficiency and the anchoring method at site.

In this Phase 5/2019, N-CODE study at Pantai Kerachut had achieved its objectives of the study, whereas it is possible N-CODE could be generating power from waves of Straits of Malacca. Finally, further studies could be done in developing N-CODE Installation Calculator for calculating optimum cost for a specific site deployment. By this, N-CODE could possibly be commercialized and preliminary for lifetime operational and calculated maintenance cost within the commercialization deployment.

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GREYWATER TREATMENT SYSTEMS DESIGN FOR DOMESTIC APPLICATION IN MALAYSIA

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Abstract

Greywater is considered more than 40 % whole domestic wastewater. Therefore, it is vital to control the discharge of greywater into the river. The application of filter media in the greywater treatment system is appropriate methods in reducing pollutants. This study proposes the design of a greywater treatment system to treat laundry wastewater in Malaysia. The proposed method implements the idea of combining five media filter materials in a compact cylinder filter. The outcome prove that the proposed system is effective in improving the quality of greywater, in which the parameters (Aluminium, Phosphorus, Fluoride, Iron, Hardness and Chloride) concentration does not exceed the treated water (tap water) quality standard. Furthermore, the proposed greywater design system is relatively suitable to be further developed for commercial use in the future.

Keywords: Environment, Greywater, Water efficiency, Water quality.

Introduction

Greywater management is an increasingly severe issue demanding attention in both developing and developed nations worldwide, mainly for Malaysia. Greywater is defined as consumer's wastewater which includes water from laundry, bathroom andZZ non-kitchen sink except of the toilet sink which contains human waste and the wastewater coming from the stream of toilet sink and the toilet bowl is commonly referred as black water (Onga et al., 2018). In general, greywater contains 50% to 80% of the household wastewater and about 75% of the total municipal wastewater (Renang et al., 2018, Salleh et al., 2011). The average greywater production per person varies between 30 to 120 litre depending on access to piped water, people's habit and their culture (Salleh et al., 2011). The fractional percentage of water usage for local household includes 22% on washing machines, 26% on toilets, 17% on showers, 2% on household cleaning as well as taking baths, while 16% of water usage is used in car washing, gardening and cleaning purposes (Rais and Mohamed, 2012).

According to Oh et al. (2018), Malaysia still does not have water quality standards for treated greywater. Domestic greywater remains a significant contributor to organic pollution in local freshwater of rivers and lake. The level of pollution concentration needs to be minimised by the domestic greywater treatment before discharging into the rivers and drains (Renang et al., 2018). Greywater recycling practices must guard against risks to public health, safety, and the environment. It has the probability to become another water source for lawn watering, agriculture and garden irrigation, groundwater recharging and toilet flushing as treated greywater has low organic and high

nutrient contents.

An Interior Customized Greywater System (ICGS) technology was proposed by Juan et al. (2016) for the family residential unit. This technology equipped design of the water usage zoning concept areas with filtering apparatus and pipeline configuration. Another researcher, like Utaberta et al. (2015) proposed the design of a greywater system that consists of several tanks for Universiti Kebangsaan Malaysia (UKM) mosque. Firstly, greywater will be treated in infiltration tank that contains activated sand followed by absorption tank and chlorination tank. In this study, locations were identified to demonstrate the pilot test for proposed grey-water treatment systems impact of water quality. This paper aims to propose local design greywater and describes the parameter of greywater water quality before and after treatment.

Material and Methods

Greywater Treatment System Design

In this study, wastewater produced from laundry service was used as greywater sample. The proposed prototype treatment system is called a NAHRIM Greywater Treatment System. This system consists of a feed tank, three stages of filtrations: micro-filtration, sediment filtration (primary filter) and ultra-filtration, several pumps and control valve, as shown in Figure 1.

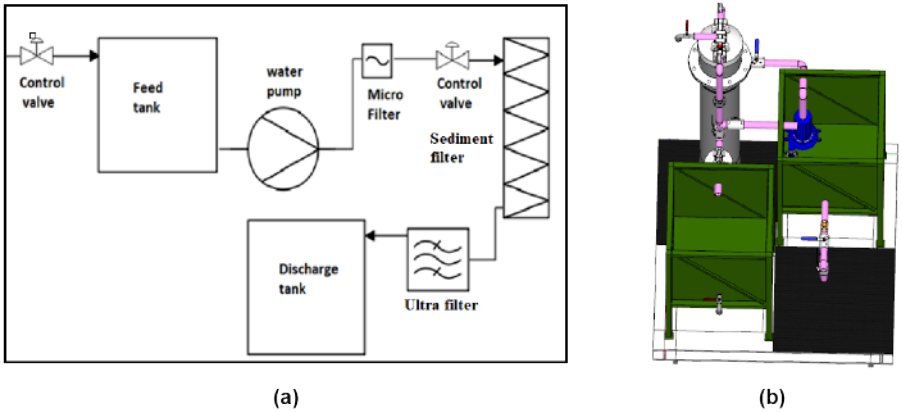


Figure 1. (a) Schematic diagram of the greywater treatment system design (b) isometric 3D view of greywater treatment system design

The wastewater treatment by using a filter media system is one of the appropriate ap-proaches to reduce the impact of water pollution on the environment. The proposed method adopts the idea of combining five basic media filter treatment processes, in a compact cylin-der filter, as shown in Table 1. Technically, potential treatment system filtration and adsorp-tion technique relatively inexpensive to build a reliable and straightforward process. The tech-nique involves separation untreated water slowly from the surface of the filter through a bed of porous sand with the influence of the water drained from the bottom.

Table 1. Filter media material of greywater treatment system design

Level	Material	Description
1	Gravel	The material gravel sourced from river gravel. The size of gravel contributes to the different effect of the water filtered.
2	Course Silica Sand	The material contains small fragments of rock, and irregular particle sizes give the ability to trap any sediments and remove dirt.
3	Zeolite	The compositions of zeolite are sodium, potassium and calcium-silicates and remove suspended solids and soluble heavy metal.
4	Anthracite	The anthracite has similar properties with activated carbon but low porous material. The adsorption occurs on the surface of the material, which provides coal ability to recycle by backwashing.
5	Activated Carbon	The active carbon high porous material with high adsorption ability. The bigger the porous of the carbon, the higher the ability of adsorption

Case Study

In this study, the greywater sample was collected from service laundry located in Section 7, Bandar Baru Bangi, Selangor, as shown in Figure 2. 12 samples were prepared in total, including for control. The greywater sample was from three washing machines for curtains (machine 1), jerseys (machine 2) and casual clothes (machine 3). The control sample randomly collected from tap water Selangor Water Supply Company Sdn. Bhd. (SYABAS). The samples of greywater before and after treatment were collected and sent to the laboratory (SGS Malaysia Sdn. Bhd) for analyses and the results obtained are summarised in Table 2



(a)



(b)



(c)



(d)

Figure 2. (a)(b)(c) The conditions at Mums Dobby laundry services (d) The comparison re-sult of greywater before (left) and after treatment (right).

Results and Discussion

Table 2 demonstrates the average values of the six parameters and its removal rate before and after treatment. Greywater sample contain fluoride with the permissible value by World Health Organization (WHO) which is below 1.5 mg/L (Shaharuddin et al., 2009). The parameter of fluoride levels was recorded at 1.1 mg/L to 0.95 mg/L after treatment and removal rate is 14 %. Besides that, the content of nutrients such as aluminium and phosphorus in greywater also decreased up to 79% and 86% respectively. Overall, the proposed system is proven to be achievable in improving the quality of greywater for reuse purposes by removing the pollutants to certain limits. As to prove the product from the system is clean and pure for drinking purpose in the future, HALAL certified for the system is advised in order to change the mindset and perception of people on treated greywater.

Table 2. The comparison before and after greywater treatment

Parameter	Before treatment	After treatment	Removal rate (%)
Fluoride (mg/L)	1.1	0.95	14
Iron (mg/L)	0.16	0.14	13
Chloride (mg/L)	22	21	5
Hardness (mg/L)	56	28	50
Phosphorus (mg/L)	4.2	0.89	79
Aluminium (mg/L)	0.22	0.03	86

Conclusions

The greywater treatment system was developed as one of the innovative products that can indirectly decrease the pressure on authorities for costly river pollution treatment, and the reuse of greywater represents a potential sustainably. It can be concluded that treated greywater samples show improvement in terms of water quality on six parameters that have been tested. On the other hand, it also can encourage and promote green technology solutions to the environment and community.

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WATER SUPPLY SECURITY OF RIVERBANK FILTRATION: A CASE STUDY OF THREE SITES IN THE PENINSULAR MALAYSIA

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Abstract

In this study, three case studies were conducted in Peninsular Malaysian to investigate and evaluate the performance of the Riverbank Filtration (RBF) process in the urban tropical regions of the country where several anthropogenic activities such as agriculture, industrial, and the municipal inflows have affected the surface water. Three different sites near the Linggi River, Langat River, and Muda River were studied on their suitability in constructing and developing the RBF systems. This paper aimed to investigate and study the selected operational RBF sites in the country (under investigation since 2012) and thereafter elucidate more potential RBF sites depending on the water issues and for that reason, geophysical data, sieve (particle size) analysis, pumping test data and water quality data techniques were carried out in this research. First, in the early stage of the investigation, geoelectric resistivity was performed to determine the suitability of the geology and the hydrogeological characteristics of the study area for establishment of RBF sites. Based on geophysical result, piezometer and test wells were drilled and developed. The pumping test was conducted to determine the factors and processes controlling the groundwater and surfacewater interaction. The hydrogeological suitability which is based on the drilling at the potential sites and then, monitoring the various water quality parameters. After evaluation, it seems that Malaysia emphasized good hydrogeological conditions which connected the river and aquifers in the three sites.

Keywords: Riverbank Filtration, aquifer, water supply.

Introduction

Malaysia has to provide potable drinking water to the additional of 31.7 million people along with the rest of the population, which already faces water scarcity. This is huge concern and has led to a major problem, especially in the dense populated urban regions along the main rivers. Hence, the sustainable water supply to the city is depending on the quality and quantity of available water and the distance between the river and the city (McIntosh 2003). According to the Malaysian National Water Policy (2012), the sustainability and security of the water resources is a very important mandate. With regards to the security of the water resources, the policies have also addressed the areas dealing with the availability of resources to fulfil the demands by optimising their potential and minimising the damaging effects on drinking water. Furthermore, the water resource sustainability policy highlights the fundamental requirement for adopting a uniform criterion to characterise these

resources, which would prioritise the allocation and the equitable usage of water, after considering the water requirement during crisis periods in their use of alternative water resources and sources. Providing safe drinking water is considered as the primary objective of the various water allocation policies that have been formed for the planning and development of the water systems. Based on the existing domestic water supply system, Malaysia could benefit considerably if RBF system is applied which is consist of suitable hydrogeological conditions. Even if RBF was used as a primary pre-treatment step for the other traditional water treatment plants, the RBF systems would provide an effective long-term solution to the water scarcity problem and decrease future huge infrastructural investments. The RBF system involves the construction of tube wells near the rivers and the infiltrated water bodies near the permeable riverbeds. Many of the European and North American studies have described the characteristic features of the feasible RBF sites depending on the importance of the parameters such as aquifer characteristics (hydraulic conductivity, thickness, flow velocity, gradient and river discharge), river hydrology and the riverbed clogging (Grischek et al., 2002; Ray et al., 2002; Schubert 2002). According to literature studies, some of the current RBF sites show a minimum thickness of 3–5 m (Bockingen near the Neckar River) and a maximum thickness of 40–55 m (Torgau-Ost near the Elbe River in Germany). Their hydraulic conductivities range between 1 x 10^{-2} to 7.5 x 10^{-5} m/s (Grischek et al. 2002). For example, the Rhine River at Dusseldorf showed a mean gradient and a flow velocity of 0.18 m/km and 1.0–1.4 m/s, respectively (Schubert 2002). This river showed a minimal and average discharge of around 800 and 2,300 m^3/s, respectively (≈100 km upstream of Dusseldorf), and the operational experience gathered over the decades indicated that the river showed a self-cleaning ability to clean the clogged regions along its riverbed (Schubert 2002). Many European countries such as the Netherlands, Hungary, Slovak Republic, Germany etc. used the RBF system for pre-treatment of drinking water (Hiscock and Grischek 2002). The Dusseldorf water system in Germany has applied the RBF technique since 1870 (Schubert 2002), while the Saloppe water system in Dresden applied the RBF system in 1875 (Fischer et al. 2006). Studies investigating the RBF processes have stated that this was a very efficient process for removing significant amounts of turbidity (Wang et al., 1995; Dillon et al., 2002; Dash et al., 2008, 2010), natural organics (Drewes et al., 2006), organic chemicals (Amy and Drewes 2006; Rauch-Williams et al. 2010), pharmaceuticals and pesticides (Miettinen et al. 1994; Ku¨hn and Müller 2000; Ray et al. 2002; Verstraeten et al., 2002; Wang 2002; Massmann et al., 2003, 2008; Greskowiak et al., 2006; Heberer et al., 2008), salinity (Dillon et al., 2002; Dillon 2009), and also the taste and odour causing compounds, which cannot be removed from the river or the surface waters using conventional treatment processes (Jüttner 1995; Worch et al., 2002). The bank filtration techniques also provide a barrier to many of the microorganisms (Havelaar et al. 1995; Schijven and Rietveld 1997; Price et al. 1999; Medema et al. 2000; Irmscher and Teermann 2002; Tufenkji et al. 2002; Wang 2002; Gollnitz et al. 2003; Weiss et al. 2003). Furthermore, the number of the Giardia sp. and Cryptosporidium cysts was decreased in the drinking waters, when sufficient flow path length and filtration times were provided (Berger 2002; Schijven et al. 2002; Gollnitz et al. 2003; Metge et al. 2007).Hence, RBF must be applied in Malaysia for removing the microbial pathogens from the drinking water, derived from the surface water. The traditional water treatment systems cannot remove many of the dissolved organic chemicals, and show low removal efficiency. During the early European industrialisation era, many cities near the Elbe, Danube, and Rhine rivers, switched from the traditional surface water treatment processes to the RBF, in order to use the natural filtration ability of the river sediments and their aquifer materials. However, the European processes cannot be directly transferred to the Malaysian environment due to the difference in hydrogeochemical, river morphology, hydrological, geological characteristics along with different well designs. The study observed that the RBF technique was a viable and useful alternative to the direct extraction of the surface water and it could provide potable drinking

water to the riparian communities. In this study, some selected feasibility Malaysian RBF sites (since 2012) were examined with different hydrogeological characteristics. This paper aimed to investigate and study the selected operational RBF sites in the country (under investigation since 2012) and thereafter elucidate more potential RBF sites depending on the water issues and for that reason, geophysical data, sieve (particle size) analysis, pumping test data and water quality data techniques were employed to carry out the research. Furthermore, this study will also provide some guidance on recharge and the optimal siting of the water treatment system depending on the water quality and the hydrogeological data. To obtain sufficient bank filtrate and prevent the clogging-related system failure, the site and river hydrology were carefully considered while designing novel RBF systems.

Materials and methods

Development of the RBFsites

Riverbank regions near the Langat, Linggi and the Muda rivers were selected for testing the RBF system in the country. The Langat Riverbank beside the Jenderam Hilir, which was located around 5 km south of the Putrajaya and identified it as the potential site for carrying out the feasibility investigation of the RBF system. This site was present between the latitudes 20 53' 28.56" N - 20 53' 39.75" N and the longitudes 101º 42' 03.78" E – 101º 44' 14.58" E and covered a 10 km2 area (Figure 3.1). Meanwhile, Kedah and Pulau Pinang beside Muda river basin and extended in the longitudes of 100º29'0" and 100º33'30" E and Latitudes 5º32'30" and 5º35'30" N. The total study area extended over a 35 km^2 area (Figure 3.5), and was near the towns of Sungai Petani (Kedah) and Kepala Batas (Pulau Pinang). Muda River was a very important water resource which supplied water for agriculture and domestic purposes to these towns. Muda River had 3 main tributaries, i.e., Ketil river, Sedim river and the Chepir river. Muda river was the longest flowing river in Kedah (180 km length), and its upstream flow originated from the mountainous northern regions of Kedah. This river flowed to the southern regions of Kedah and showed a 4210 km^2 catchment area. Downstream, this river shifted its course to the west and formed a confluence between the main river and its largest tributary, i.e., Ketil River. The study area's quaternary stratigraphy was further divided into the Beruas and the Gula Formation. The Beraus Formation was the uppermost layer and consisted of the brown-coloured holocene terrestrial sediments. Below this Beruas Formation was the Gula Formation, which was made of silt, clay, and shell-filled sand. The Gula Formation was made of an impermeable layer and confined all other formations below it. This region was selected for RBF analysis as it had a high water demand and groundwater could be a supplementary source for fulfilling the high water requirement. While, the RBF study at the Linggi Riverbank located at Water Treatment Plant beside the Linggi Riverbank. This Linggi River Water Treatment Plant supplied about 60% and 100% water to the regions of Seremban and Port Dickson, respectively (Figure 3.4). During the primary investigation, the geo-electrical studies were carried out for investigating the subsurface geology of the area and the thickness and depth of the potential aquifer system were determined. Also, the resistivity traverse for investigating the interactions between the surface and the ground waters using similar procedures for determining the geological suitability along with the hydrogeological characteristic features of the region was carried out. The Schlumberger array for resistivity traverses as it provided dense near-surface coverage for their resistivity data was used. The resistivity using the resistivity metre and an ABEM Terrameter LS 1 system for collecting data were determined. All data collected in the study was interpreted using the RES2DINV software (Loke et al. 2003), which provided an inverse model which approximated the actual subsurface structures. Inversion algorithm by RES2DINV for data processing and obtaining the resistivity section (Loke and Barker 1996) were used. Software,

RES2DINV used the inversion process, based on a robust constrained process. In this method, the 2D model, applied in the subsurface, is further divided into many rectangular blocks. Thereafter, the resistivity of these rectangular blocks is adjusted iteratively for minimising the variation between the calculated and the measured apparent resistivity values. After determining the resistivity of the different materials, it becomes easier to convert the obtained resistivity image to the subsurface image consisting of various materials. The traditional process of plotting all results is carried out with the help of the pseudo section that gives the approximate image describing the subsurface resistivity distribution. Shapes of the contours are based on their array geometry and their subsurface resistivity (Kneisel 2006). Depending on geophysical results and their interpretation, the piezometers (i.e., observation well) and the pumping test wells was drilled and developed. This drilling was carried out for establishing a subsurface geology and the depth of the water table in the identified regions near the study area was determined. Furthermore, the sieve analysis of the soil material for supporting the preliminary geophysical results and the data for the geological bore log obtained from the piezometer wells also carried out. Determined the necessary soil parameters for estimating the hydraulic conductivity from the sieve analysis was determine. Hydraulic conductivity (K) is an important parameter for measuring the travel time between the various depths and was determined as proposed earlier (Hazen 1911; Kozeny 1953). This travel time between the piezometer screens, test wells and riverbank was an important factor for the removal of turbidity and microbes from the water and hence, a 72 hrs pumping test was carried out. A step-drawdown test (5 steps), 72 h constant discharge test and the recovery test were carried out for every test well. The pumping rates during the pumping tests using the V-notch weir were also measured. Automatic data loggers were kept in the test wells for estimating the groundwater levels. The pumping test at a constant rate was carried out for longer durations for ascertaining its effect on the nearby regions, especially the riverbeds. A submersible pump was also installed below the ground level. After installing the pump and other necessary setups, and conducted a calibration test for 2 h for determining the test well capacity. Thereafter, the recovery test after completing the continuous discharge test was immediately conducted. The pumping test results for studying the hydraulic properties of these test wells were used. The extracted water quality from the piezometers and the test wells using a 72 h pumping test were monitored. water samples from the test wells, piezometers and the rivers for studying the relationship between the quality of the surface waters and the ground waters and the concentrations of the contaminants present in the rivers while conducting the pumping test were collected. Similar experiments were carried out during the continuous discharge test for the test wells. The water samples every 24, 48 and 72 h was collected. The water sample collection technique and sample analysis were carried out as per the American Public Health Association (APHA) (APHA 2005) standards. The collected water samples were stored at 4°C for decreasing the microbial activity (APHA 2005). It was seen that colloidal and suspended particulate matter interfered with the metal analysis. Hence, after the samples were transported to the labs, the samples were filtered immediately using a 0.45-µm cellulose acetate membrane filter (Whatman Millipore, Clifton, NJ). This process prevents the clogging during the spectrophotometric analysis and during estimation of the dissolved ions. Thereafter, the water samples were acidified using HNO_3 and the pH decreased below 2, as it prevented the precipitation of other components like hydroxides and metal oxides and also, decreased the microbial activity. Furthermore, the multi-parameter probes (SevenGo pro probe; SevenGo Duo pro probe, Mettler Toledo AG, Switzerland) was used for measuring the TDS, Electrical Conductivity (EC), and pH in situ. Calibration of these probes was carried out before their usage. The unfiltered samples were subjected to an on-site analysis for the bicarbonate (titrating with 0.02 N HCl) and the chloride ions (using the argentometric method with 0.0141 N $AgNO_3$) (APHA 2005). On the other hand, the filtered water samples were divided into 2 polyethylene bottles, where one bottle was used for

determining the sulphate ion concentration (using the SurfaVer 4 HACH method) and the nitrate ion concentration (using the NitraVer 5 HACH method); while the other bottle was used for determining the cations and metal ions concentration. Cations concentration was determined by the flame atomic absorption spectrometry (FAAS, Shimadzu AA6800), while the trace metal concentration was determined using the Inductively Coupled Plasma- Mass Spectrometry (ICP-MS, ELAN DRC-e, Perkin Elmer). All these tests were conducted at the Geochemical Laboratory, Department of Chemistry, Malaysia. In the case of the groundwater samples, the test wells were pumped for around 30 min. 36 water-quality parameters, including: pH, colour, turbidity, EC, manganese (Mn), iron (Fe), nitrate-nitrogen (NO_3–N), nitrite-nitrogen (NO_2–N), Total Solids (TS), Total Dissolved Solids (TDS), arsenic (As), silver (Ag), aluminium (Al), ammonium (NH4), barium (Ba), bicarbonate (HCO_3), carbonate (CO_3), cadmium (Cd), calcium (Ca), chloride (Cl), chromium (Cr), cobalt (Co), copper (Cu), fluoride (F), potassium (K), phosphorus (P), sodium (Na), nickel (Ni), magnesium (Mg), mercury (Hg), selenium (Se), sulphate (SO_4), silica (SiO_2), strontium (Sr), and zinc (Zn) were tested. The concentrations of the major anions, cations and heavy metal ions were determined by the ion chromatography. The trace element concentrations were determined by ICP and Atomic Emission Spectrometry (ICP-OES) in situ. The concentrations of Na, Fe, Mn, Ca, K, and Mg ions were estimated by the Atomic Absorption Spectrophotometry (AAS). All concentrations have been expressed in milligrams per litre (mg/L), except for the EC or pH values. The total coliform and the E. coli counts were measured with the help of the Most Probable Number (MPN) technique, using Colilert (Idexx Corporation, Westbrook, Maine) at the NAHRIM's Laboratory. The Colilert is a commercial liquid medium which helps in simultaneously detecting the E. coli sp. and the total coliform count. This method uses a specially designed disposable incubation tray, i.e., the Quanti-Tray. In the MPN analysis, 2 enzyme substrates were allowed to react in Colilert, where one was a chromogen which reacted with the galactosidase enzyme, indicating the presence of the total coliforms. The next substrate was a fluorogen which reacted with glucuronidase, released by the E. coli sp. The samples were incubated for 24 hrs 35 °C. If the medium had turned medium yellow, it indicated a positive total coliform reaction, while a positive E. coli caused the fluorescence of the medium under a long-wave UV light (366 nm).

Results and discussion

RBF systems

Langat River

In this area, the aquifer system was shallow and comprised of the alluvial deposits made of silt, sand, and gravel. The aquifer was made of a fine and coarse mixture of sand and gravel and had a thickness of 5-20 m. Presence of the fine and coarse sand made this system locally heterogeneous. Also, the unsaturated aquifer zone was made of clay having a thickness of 1-3 m. The geophysical profile of L1-L1' and L2-L2' were approximately parallel to the Langat River (Figure 3.1). Figures 3.2 and 3.3 show the L1-L1' and L2-L2' profiles, respectively, which had a penetration depth of 60 m and their survey line length was 320 m. Generally, the 2D profile based on the geo-electrical survey showed 3 forms of materials in the aquifer system: (a) Permeable materials that were water saturated; (b) Semi-permeable materials (c) Semi-permeable materials that were weathered to form fresh rocks. The water saturated permeable soil comprised of permeable rocks and soil and had a low resistivity ranging between 0-120 ohm.m, which was attributed to the presence of the water between the pores of the soil. Lower resistivity values indicated the groundwater aquifer system. The second semi-permeable layer showed the resistivity values ranging between 120 and 800 ohm.m, while the weathered and fresh rock materials showed a resistivity value ranging between 800 and 5000 ohm.m. The resistivity images in Figures 3.2 and 3.3 showed

that the aquifer system did not contain any major geological structural faults. The minor geological structures like foliations and joints led to the presence of water in this sub-surface layer. Denser geological structures in this area improved the groundwater levels. The L1-L1' and L2-L2' profiles (Figure 3.2 and 3.3) showed the presence of the groundwater aquifer at this site. Results indicated that the recharge of these groundwater sources from the lake or the river was prevented due to the rocks, semi-permeable and impermeable materials which were present in the geological sub-surfaces of this region. This indirectly led to different groundwater quantities (groundwater storage) in the region. The amount of groundwater in this aquifer system can be estimated with the help of the pumping tests. The RBF flow was not the dominant groundwater recharge in the region because of the presence of the hindering materials. The permeable and semi-permeable materials which cross one another in the subsurface profiles restrict the mixing of the recharge from various sources with this groundwater aquifer. The low resistivity values (shown in blue) present in images could be interpreted as (a) The groundwater aquifers (shallow or deep aquifers); (b) The presence of the Shale and Siltstones and (c) The presence of the Schist Graphite. These groundwater aquifers consist of permeable materials like sand and gravel, which decreased the resistivity values (ranging between 5-100 ohm.m). Furthermore, the heterogeneous layers of permeable and water-saturated sand and gravel (contributed to the fluid-filled pores) lead to large groundwater flow through these pores. Thus, the resistivity measurements are affected by the fluid in the pores instead of the mineral composition of this soil, which makes the resistivity values very apparent. Also, the dissolved ion concentration in these fluids helps in controlling the groundwater's ability to transmit electricity (Sherif et al. 2006). The presence of the groundwater in this region was attributed to the combined presence of the deep groundwater aquifer and a shallow aquifer (RBF). This led to the development of a leaky aquifer (i.e., un-continuous impermeable layer) between the deep and the shallow aquifers. This deep aquifer was present 60 m below the surface. Furthermore, the presence of semi- or impermeable materials like shale, siltstones and schist graphitic lead to low resistivity values (Figure 3.2 and 3.3). According to Poulsen et al. (2010), the presence of large amounts of clay in the soil sediment makes it a good conductor. As shown by the geological conditions, observations of this study and the bore-log analysis, shale and siltstones were present in many extended and deep regions in this area. The presence of these semi-permeable or impermeable materials (shown at the right side, Figure 3.2 and 3.3) provided the advantages of the RBF approach. The extraction of the groundwater at the proposed TW1 and TW2 sites, which concentrated and extracted waters from the Langat River, were hindered due to the presence of the impermeable materials which prevented the groundwater flow. The above-mentioned explanations could be verified by carrying out site investigations for obtaining a sub-profile of the materials for the depth of 60 m. The bore log analysis revealed the presence of dominant permeable materials (like sand and gravel), which indicated that these regions had a leaky aquifer (a combination of shallow and deep aquifers). On the contrary, impermeable materials like shale, siltstones and schist graphite were also present which prevented the flow of the groundwater to the TW1 and TW2 sites. After carrying out drilling studies, the gravelly sand and the sandy gravel aquifer layers were overlaid with a clay layer, whereas some of the regions were overlaid by a silt of a semi-permeable sand layer, which made this aquifer either unconfined or semi-confined, based on its location were observed. Analysis also revealed the presence of bedrock at the depth of 20 m. The sandy gravel had a high transmissivity and porosity, and was connected to the river. This allowed the recharge of the aquifers during the higher river flow. However, during the low flow of the river, the groundwater was discharged in the river. The recharge rate of the groundwater and the river was dependent on the thickness of the hyporheic zone. The mean monthly river flow at this site was 32.15 m3/s, while 80% of the dependable flow for the Langat River was 19 m^3/s were determined. Studies have shown that the mean low flow for the river was 4.76 m^3/s for the period ranging between 1978 and 2013. The Langat Riverbed

permeability was 0.4 m /day. The river survey showed that the river had a cross-sectional single thread channel, where the full width between its banks ranged between 22.75 and 50.20 m, which indicates that the Langat River was a medium-sized river. 2 test wells i.e. TW1 and TW2, with a 250 mm outer diameter, depth of 14.50 m and 15.42 m., respectively for determining the hydraulic parameters for the wells and the aquifer were constructed. A pumping test at the TW2 at the rate of 12.90 m^3/h where the static water level was 3.24 m below the top of casing (TOC) were carried out. A constant flow rate of 64.50 m^3/h was maintained throughout the experiment. At the end of day 1 of the pumping test, a total drawdown of 3.16 m was seen. Also, the recovery test in the TW2 after the step-drawdown test showed that the water levels recovered to 3.53 m after a 7 h pump stop at 90.82% efficiency. Thereafter, the static water level was at the depth of 3.50 m, while the final level was observed 7.03 m below the ground surface level. Values for T and K for the TW2 were 42.16 m2/h and 2.72 m/h, respectively. The results of the aquifer test showed that the travel time of the river water for recharging the aquifer ranged between 3 and 4 days. This travel time was determined by dividing K (m/day) by the thickness of the aquifer. Results of the TW2 showed that a properly constructed well along the banks of this river could yield a high volume of potable water. The recovery results of the TW2 showed that the 4.2 m below ground level (bgl) water was recovered from the final water level (7.03 m bgl) within 1 h, i.e., 80%, which decreased thereafter. In the case of the TW1, where a step-drawdown test (3 steps) was applied, a continuous discharge test for 72 h was carried out. This pumping test was initiated at the rate of 6.53 m^3/h, where the static water level was 6.47 m below the TOC. A constant flow rate of 10.10 m^3/h was maintained throughout the experiment. At the end of day 1 of the pumping test, a total drawdown of 0.97 m was seen. Also, the recovery test conducted in the TW1 after the step-drawdown test showed that the water levels recovered to 6.66 m after a 1 h pump stop at 80.41% efficiency. Thereafter, the static water level was at the depth of 6.09 m, while the final level was observed 7.45 m below the ground surface level. Values for T and K for the TW1 were 9.24 m^2/h and 0.63 m/h, respectively. The TW1 drawdown was quite low, which indicated that though this well could generate a high volume of water, the limitations due to the aquifer layer and the pressure of the thick clay layer above the aquifer, decreased the recharge by the river was observed. The aquifer test indicated that the travel time of the river water for recharging the aquifer ranged between 1 and 4 days.

Linggi River

35 exploration wells having a 50 mm diameter as a part of the preliminary assessment of the groundwater in this region was constructed. Based on the data obtained from these exploration wells, 6 more wells, wherein 5 of the wells were constructed in the alluvium layers and the one was present in the hard rock layer. The 5 wells, constructed in the alluvium layers, had a depth ranging between 6-13 m and diameter of 254 mm, whereas the hard rock well had a 36 m depth and 152 mm diameter. The geophysical profile of L1-L1' were approximately parallel to the Linggi River.(Figure 3.4) The hard rock well showed a discharge of < 5 m^3/h during drilling, while the alluvial layer wells showed a water discharge ranging between 28- 65 m^3/h. After drilling with a piezometer (100 mm diameter), a yellowish brown soft clay material with decayed wood fragments at a 2 m depth, while dark grey silt material was observed at a 3.5 m depth were observed. Further drilling yielded a dark grey fine-grain sand with some traces of clay at a 5.5 m depth, followed by the dark grey medium and coarse sand with dark grey silt and fine-grain sand at the depths of 7.2 m. Finally, the schist bedrock was observed. Shallow alluvium units having a diameter of 50 mm and 2 shallow alluvium units with a diameter of 150 mm using a 35 piezometer in alluvium unit were constructed along the Linggi River riverbank with 50mm diameter and two piezometers with

150 mm diameter, respectively. a step-drawdown test on the SL-TW1 test well, which consisted of 5 discharge steps, and the duration of every step was 90 min. 4 discharge steps were conducted at 5.5 m^3/h, 6.5 m^3/h, 7.5 m^3/h and 8.5 m^3/h were carried out. Also, the initial level of static water was 1.30 m below the ground surface level, while the final level was 2.83 m below the ground surface level, and the total drawdown was 0.52 m. A constant discharge flow rate of 7.96 m^3/h was maintained for the SL-TW1 tube well. This was the maximal capacity of the submersible pump used in the test.

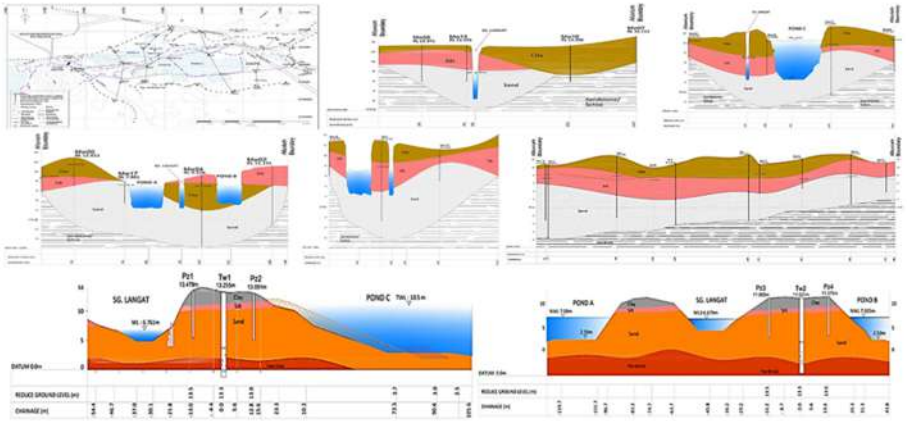


Figure 3.1. A simplified map of the study area and schematic profile of Langat River (Sg. Langat).A is crosssection of AA', B is crosssection of BB', C is crosssection for CC', D is crosssection for DD', E is crosssection for EE', F is cross section of TW1 test wells and G is crosssection of TW 2 test wells

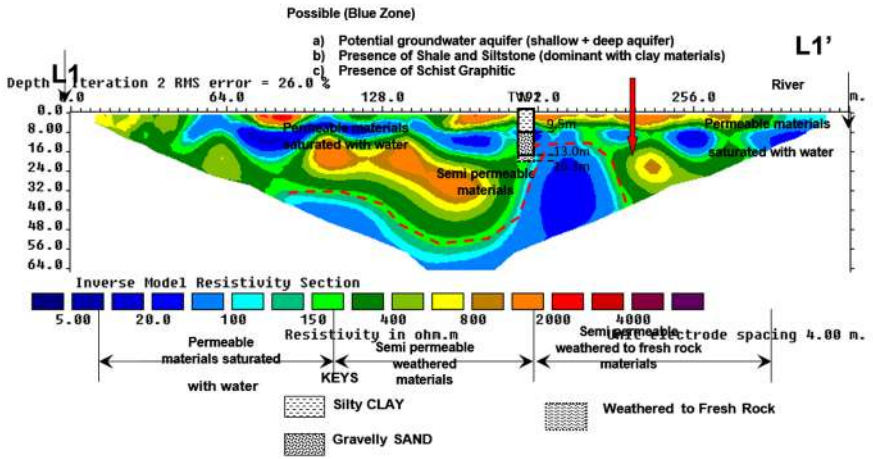


Figure 3.2. The 2-D image profile for the survey line L1-L1' at the site of Langat river

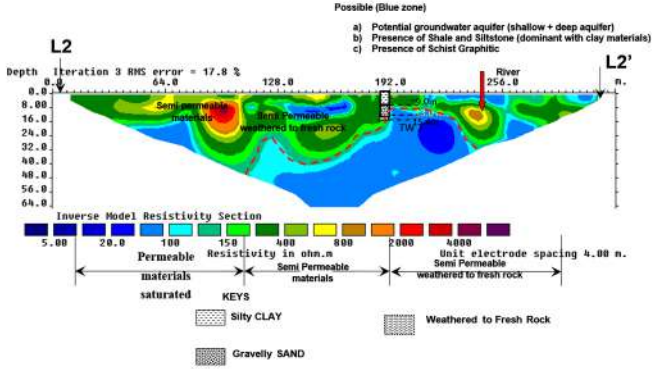
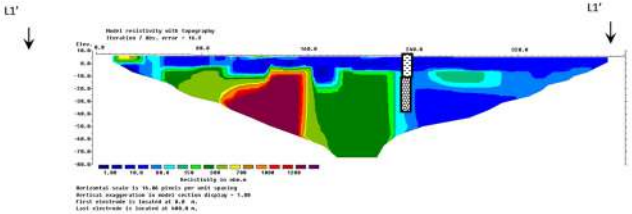
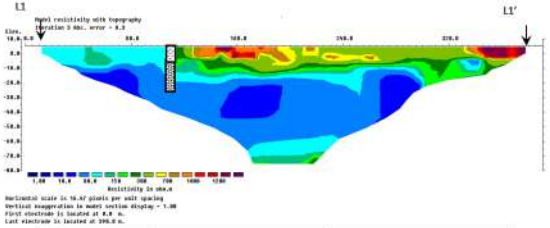


Figure 3.3. The 2-D image profile for the survey line L2-L2' at the site Langat river



No	Resistivity Value (Ωm)	Resistivity Legend	Interpretation
1	0 ~ 120	1.00 10.0 80.0	Permeable Soil saturated with water (possible groundwater)
2	150 ~ 700	150 300 700	Semi permeable soil and weathered rock
3	700 and above	10 1000 1200	Impermeable soil or rock (Unsaturated zone)

Figure 3.4. The 2-D image profile for the survey line L1-L1' at the site of Linggi river



No	Resistivity Value (Ωm)	Resistivity Legend	Interpretation
1	0 ~ 120	1.00 10.0 80.0	Permeable Soil saturated with water (possible groundwater)
2	150 ~ 700	150 300 700	Semi permeable soil and weathered rock
3	700 and above	10 1000 1200	Impermeable soil or rock (Unsaturated zone)

Figure 3.5. The 2-D image profile for the survey line L1-L1' at the site Muda river

Thereafter, the static water level was seen to be at the depth of 1.1 m, while the final level was 2.37 m below the ground surface level, after pumping nonstop for 72 h, and the total drawdown of 1.27 m was noted. The well showed a transmissivity value of 1.37 m2/h. In the recovery test, the tube well achieved an 80% recovery from its initial static levels. The whole recovery test was conducted for 4.5 h. The results showed that the initial residual drawdown was 2.37 m, while the residual drawdown after pumping for 4.5 h was 0.3 m, and a 76.38% recovery was observed. The recovery test showed a transmissivity value of 18.21 m^2/h. A continuous discharge test was carried out for the SL-TW2 for determining the aquifer characteristics. The groundwater level drawdown while conducting the pumping tests at the piezometers wells (SL-MW11, SL-MW12, SL-MW13, SL-MW14, SL-MW15 and JL13) also was measured. The constant pumped for 72 h at the rate of 17.1 m^3/h and the final drawdown was 7.24 m, while the total drawdown was 5.65 m. The piezometer wells showed a total drawdown ranging between 0.69 and 1.05 m. Based on these results, the SL-TW2 showed a hydraulic conductivity of 17.1 m/day, while the monitoring wells showed a hydraulic conductivity ranging between 54.1 and 63.1 m/day, with a mean hydraulic conductivity of 53.1 m/day. The test well showed a transmissivity value of 102 m^2/day, ranging between 325 to 379 m^2/day for the monitoring wells, with a mean transmissivity value of 319 m^2/day. After completing the discharge test, the recovery test for 120 min after shutting the pump was immediately carried out. For this period, the SL-TW2 test well showed a drawdown of 0.2 m, while the monitoring wells showed a drawdown ranging between 0.15 and 0.64 m.These results showed that the SL-TW2 test well had a hydraulic conductivity of 16.7 m/day, while the monitoring wells showed values ranging between 38.8 and 51.1 m/day, with a mean value of 43.0 m/day. Transmissivity values for the SL-TW2 were 100 m^2/day, and for the monitoring wells, the values ranged between 233 and 306 m^2/day, with a mean value of 258 m2/day. According to the Kozeny-Carman equation, these wells showed a hydraulic conductivity ranging between 3.6 and 174.6 m/day, with a mean of 48.5 m/day. The Hazen equation showed that the hydraulic conductivity ranged between 6.79 and 202.7 m/day, while the mean value was 61.4 m/day. These values were compatible with the results obtained from the grain size analysis that showed that this region predominantly contained medium to coarse grains of sand. The constant and the recovery tests showed transmissivity, T, values ranging between 100 and 379 m^2/day, with a mean of 257 m^2/day. Using the discharge test equipment that was used for the pumping test, the storage coefficient, S, which had values ranging between 4.17×10-4 and 2.6×10-1, with a mean value of 3.93×10-2 were obtained.

Muda River

15 monitoring and 2 test wells was constructed in this site and carried out pumping tests for the 2 test wells. According to the pumping test results that were carried out for 72 h, TW1 generated 43.92 m^3/h water while TW2 generated around 51.609 m^3/h and the drawdown for TW1 and TW2 were 3.22 m and 1.88 m, respectively. The water quality of the Muda River and the groundwater were analysed. Analysis showed that the groundwater was less turbid and had a lower concentration of aluminium, nitrate, and sulphate ions. The Muda Riverbank aquifer system consisted of alluvial deposits with silt, sand, and gravel, and these formed a confined shallow aquifer. The geophysical profile of L1-L1' were approximately parallel to theMuda River. (Figure 3.5). Furthermore, the unsaturated zone in the aquifer consisted of a sandy silt layer having a thickness of 1 - 3 m. This aquifer was made of fine and coarse-grains of sand and gravel and had a thickness of 3-25 m. This layer could be heterogeneous due to the presence of fine and coarse-grained sand beds. After carrying out drilling tests the sandy gravel/ gravelly sand layer was overlaid by the clay layer was observed, while some areas were overlaid by the silt or fine sand layer, which semi-confined or confined the aquifer, based on its location. This site consisted of a marine clay

layer at a 25 m depth. This aquifer was recharged by the river and the rain waters which infiltrated the aquifer. All results showed that the groundwater and the river water were interdependent. The river waters easily recharged the aquifers during its high flow since its sandy gravel layer had a high transmissivity and porosity (based on its particle size analysis of the test and the monitoring wells) and the aquifer was connected to the Muda River channel. However, during its low flow, the groundwater recharged the river based on its location. Figure 3.5 presents a schematic cross-section of hydrogeological parameters of the Muda River aquifer system, based on the borehole logs for 22 monitoring and 2 test wells. Figure 3.6 described the location map and the hydrogeological cross-section diagram for the bank filtration at the selected sites for TW1 and TW2.

Quality characteristics of water extracted during the pumping test

Comprehensive water analyses were conducted to assess the suitability of the river water in terms of portability via direct treatment or RBF. The samples analyzed were representative of a site near the riverbank of rivers in the study area. The physicochemical parameters of the surface-water and groundwater samples collected from the Langat River RBF (TW1 and TW2, Pond A, Pond B, Pond C, Upstream and downstream river), Linggi River RBF (SL-TW1 and SL-TW2 and monitoring wells SL-W11, SL-W12, SL-W13, SL-W14, SL-SW15, JL-4, JL-5, Upstream and downstream) and Muda River RBF (TW1 and TW2 and upstream and downstream river) during a constants discharge pumping test for 24, 48 hr and 72 hr and percentage of change for the water quality are presented in Table 3.4, 3.5 and 3.6. All parameters result is compared with National Drinking Water Quality Standard. Analysis water samples from test well (TW1 and TW2) shows that almost all parameter are within acceptable value standard for raw water except parameters such as Ferum (Fe), Manganese (Mn) and Ammonia (NH3-). It means that more time pumping test was held, the concentration of above parameters become good in quality but still above acceptable value standard. Based on compares of water quality between four (4) test wells (DW1, DW2, TW1 and TW2) shown that only a few parameters have quality above acceptable value.

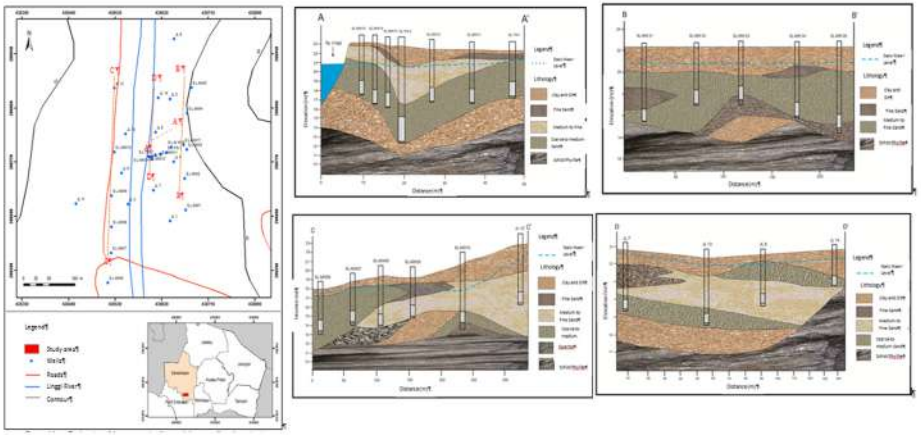


Figure 3.6. The location of the cross section lines (AA', BB', CC'and DD') and the test wells and monitoring wells at the study area

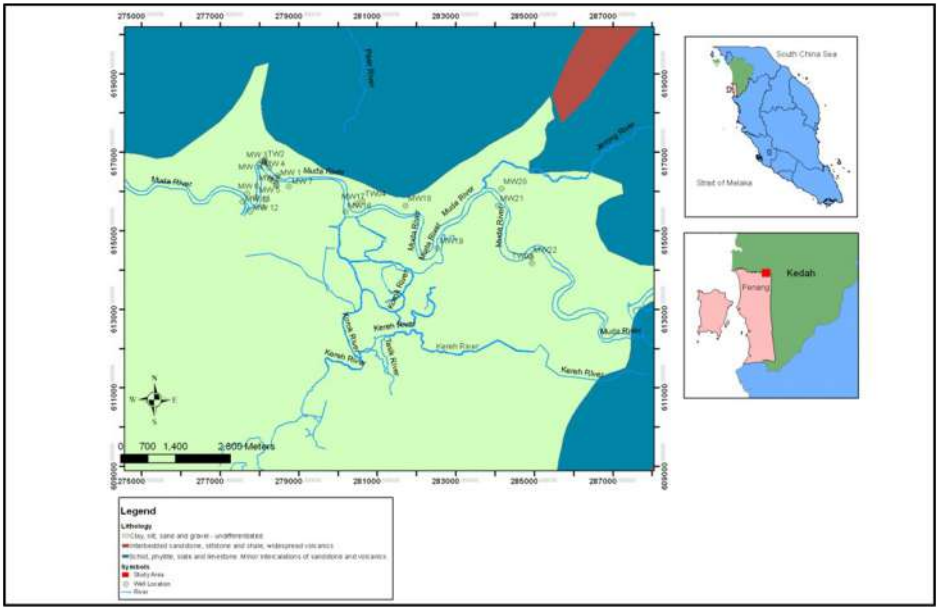


Figure 3.7. Location of wells and surfacewater resources at the study area of Kedah and Penang

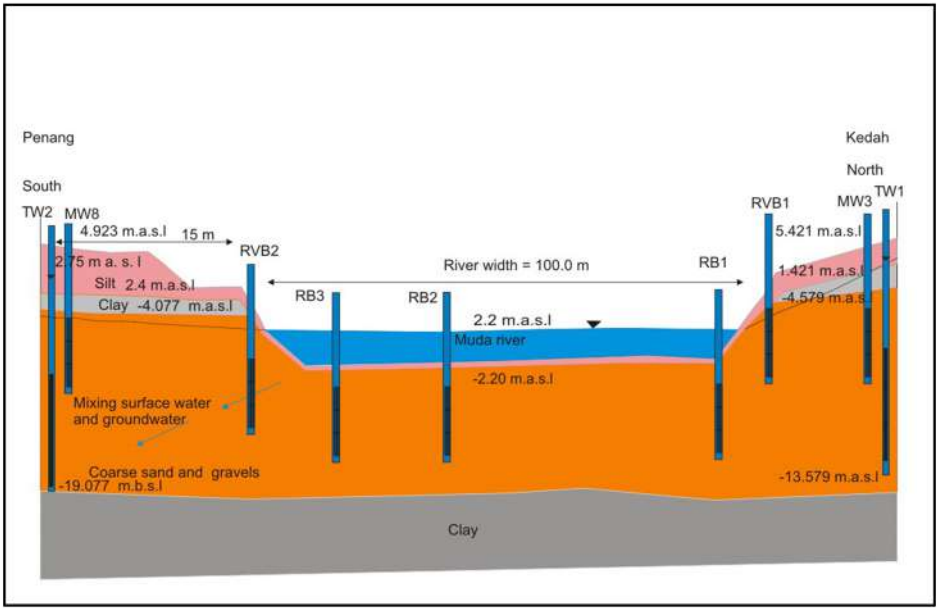


Figure 3.8. Schematic of cross section of Muda River and between 2 states Kedah and Penang

Table 3.4. Water quality during pumping test (abstraction), for period of 24 hours, 48 hours and 72 hours and percentage removals of chemicals at TW1 and TW2 wells, Pond A, Pond B and Pond C and Langat River and Drinking Water Standard, Department of Standard Malaysia (DSM), (2010).

Parameters/Analysed	unit	TW 1			TW 2			Pond A	Pond B		Pond C		River water S1 (upstream Langat River)	River Water S2 (confluence with Semenyih River)	River water S3 (downstream Langat River)	Drinking Water Standard (2010)	Percentage removals of S2 solution
		(1hr)	(48hr)	(72hr)	(1hr)	(48hr)	(72hr)	1 m (from surface)	0.5 m (from bottom)	1 m (from surface)	0.5 m (from bottom)	1 m (from surface)					
		Day 1	Day 2	Day 3	Day 1	Day 2	Day 3										
pH		8.06	6.16	6	6.2	5.56	6.4	7.24	6.74	6.55	6.32	8.28	6.83	8.71	6.78	6.5-9.0	0
Colour	H.U.	<5	30	10	<5	10	5	ND (<5)	10	ND (<5)	ND (<5)	ND (<5)	30	30	30	15	0
Turbidity	N.T.U	114	306	362	53	60	48	11	99	22	2	2.1	143	137	300	5	98
Conductivity	µS/cm	101	90.7	84.3	78.9	81.5	80.3	158	147	148	78.9	74	155	53	137	-	0
SiO_2	mg/l	10	11	15	16	8.64	8.9	1		ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	ND (<1)	-	55
Tot. Solid	mg/l	83	111	54	53	65	61	100	90	71	41	64	64	107	53	-	68.18
Diss. Solid	mg/l	98	16	36	60	86	68	30.61	88	54	120	90	86	83	5.68	1000	30.61
HCO_3	mg/l	44.5	38.3	32.1	32.1	39.3	33.1	51.8	42.4	45.5	23.8	25.9	43.5	41.4	42.4	-	36.54
Cl	mg/l	5.12	6.88	7.69	7.19	8.57	5.88	8.12	20.2	8.19	5.34	5.39	6.33	7.56	7.09	250	98
SO_4	mg/l	1.93	3.85	2.72	3.45	4.25	2.96	14.4	19.6	12.6	5.89	6.43	17.1	18.6	15.5	250	83.33
NO_2	mg/l	ND(<0.02)	0.04	0.02	0.03	0.04	ND (<0.02)	0.23	0.75	0.2	0.03	0.03	0.5	0.48	0.6	10	98.94
NO_3	mg/l	0.04	1.42	0.69	0.73	0.53	0.37	1.8	0.41	0.98	0.61	0.34	5.55	5.47	5.91	10	97
F	mg/l	0.232	0.224	0.306	0.187	0.18	0.18	0.139	0.169	0.162	0.197	0.192	0.155	0.123	0.131	0.4-0.6	0
P	mg/l	0.17	0.16	0.18	0.1	0.279	0.12	0.07	0.03	0.04	0.01	0.01	0.14	0.09	0.13	-	0
NH_3	mg/l	3.2	2.2	1	1.7	1.6	1.6	1.18	0.41	0.98	0.61	0.34	0.66	0.37	0.3	1.5	0
Al	mg/l	0.57	0.035	0.1	0.072	1.03	0.07	0.25	0.561	0.472	0.05	0.062	3.49	2.04	5.91	0.2	93
As	mg/l	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (<0.001)	ND (<0.001)	ND (<0.001)	0.01	40
Ca	mg/l	8.4	10	11.9	11	12.9	15	4.1	3	3.96	4	2.61	2	2.1	2.5	-	47.37
Fe	mg/l	17.4	28.5	27.5	11	12.5	3.2	0.559	0.886	0.773	0.237	0.182	3.11	2.17	4.43	0.3	0
K	mg/l	6	3.48	5.4	3.37	3.48	3.68	0.25	0.561	0.472	0.05	0.062	0.061	0.05	0.014	-	0
Mg	mg/l	2.94	2.66	2.51	2.01	2.23	1.92	20.7	1.88	1.98	1.4	1.55	1.99	1.74	2.02	150	0
Mn	mg/l	0.868	0.764	0.735	0.759	4.84	0.704	0.182	0.166	0.151	0.04	0.014	0.089	0.094	0.131	0.1	0
Na	mg/l	8.79	4.28	4.56	5.25	4.33	5	14.1	11.3	11.6	7.8	7.39	11.2	8.19	7.48	200	67.15
Zn	mg/l	0.077	0.042	0.049	0.032	0.076	0.039	0.104	0.036	0.043	0.011	0.0011	0.203	0.081	0.075	3	0
Cd	mg/l	ND(<0.002)	ND(<0.002)	ND(<0.002)	ND(<0.002)	ND(<0.002)	ND(<0.002)	ND (<0.002)	ND (<0.002)	ND (<0.002)	ND (<0.002)	ND (<0.002)	ND(<0.002)	ND(<0.002)	ND(<0.002)	0.003	0
Co	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0	<0.05	<0.05	<0.05	<0.01	<0.01	<0.01	0	1	0
Cr	mg/l	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	ND (<0.010)	0.05	0
Cu	mg/l	0.077	0.041	0.105	0.019	0.038	0.092	0.036	ND < 0.004	0.021	ND <0.004	ND <0.004	0.015	0.018	0.021	1	0
Hg	mg/l	ND(<0.0008)	ND(<0.0008)	ND(<0.0008)	ND(<0.0008)	ND(<0.0008)	ND(<0.0008)	ND (<0.0008)	ND (<0.0008)	ND (<0.0008)	ND (<0.0008)	ND (<0.0008)	ND(<0.0008)	ND(<0.0008)	ND(<0.0008)	0.001	0
Ni	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0	<0.1	<0.1	<0.1	<0.01	<0.01	<0.01	0	0.02	0
Pb	mg/l	<0.1	0.1	<0.1	<0.1	<0.01	<0.1	0	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	0	0.01	0
Se	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0	0.01	0
Sr	mg/l	0.03	0.02	0.02	0.04	0.03	<0.01	0	0.03	0.03	0.03	0.03	0.03	0.03	0	-	0
Ag	mg/l	<0.5	<0.5	<0.05	<0.5	<0.05	<0.05	0	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0	0.05	0
Ba	mg/l	<0.1	<0.1	<0.1	0.3	<0.01	0.2	0	<0.1	<0.1	0.2	<0.05	<0.05	<0.05	0	0.7	0
Carbonate Hardness	mg/l	110	68	37	26	42.4	56	49.09	66	34	92	39	42.4	44	33.33	500	33.33

Table 3.5. Water quality during pumping test (abstraction), for period of 24 hours, 48 hours and 72 hours and percentage removals of chemicals Linggi River (SL-TW1 and SL-TW2 and monitoring wells SL-W11, SL-W12, SL-W13, SL-W14, SL-SW15, JL-4, JL-5, Upstream and downstream) and Drinking Water Standard, Department of Standard Malaysia (DSM), (2010)

Parameter	unit	Linggi River	JL13			JL4			SLMW15			SLMW14			SLMW13			SL-MW12			SLMW11			SLTW2			SLTW1			DSM 2010 standard		WHO 2010	DOE standard	Percentage removal of BOD, COD, SS and Ammoniacal Nitrogen
		24hr	24hr	48hr	72hr	24hr	48hr	72hr	24hr	48hr	72hr	24hr	48hr	72hr	24hr	48hr	72hr	24hr	48hr	72hr	24hr	48hr	72hr	24hr	48hr	72hr	24hr	48hr	72hr	Raw Water	Treated Water			
Temperature	oC	27.5	27.8	27.33	26.8	27.2	27.4	26.6	27.3	27.46	27.6	27.2	27.45	27.4	27.3	27.26	27.5	27.1	27.32	27.1	27.2	27.5	27	27.8	27.95	27.2	27.3	28	26.6					0.0
Turbidity	N.TU	191.3	135	167	200	176	141	126	0.3	0.4	0.8	2.8	0.2	0.5	0	0.5	0.6	1.5	0.5	0.6	174	232	142	5.5	2.4	1.9	4.4	0.5	0.5	1000	5			99.7
Colour	HU	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	300	15			0.0
pH		6.7	6.7	6.2	6.5	6.6	6.4	6.5	6.7	6.4	6.3	6.6	6.4	6.3	6.7	6.5	6.4	5.58	5.39	6.96	6.6	6.1	6.6	7	6.9	6.6	6.8	6.4	6.7	5.5 - 9	6.5 - 9			0.0
EC	uS/cm	117	181	138	128	158	128	122	165	154	176	157	145	145	156	132	165	250	252	244	157	135	168	103	93	159	157	169	103					12.0
DO	%	106.5	62.8	52.5	75.3	73.5	64.1	53.6	52.4	39.7	37.3	69.8	49.9	44.1	76.2	44.9	44.4	57.5	38.7	39.8	59.4	43.6	39.6	35.7	54.8	337.9	70	51.8	58.5					45.1
Mn	mg/l	0.2	0.9	0.8	0.8	0.8	0.7	0.8	0.7	0.8	1	0.9	0.7	0.8	0.6	0.5	0.8	0.8	0.8	0.8	0.7	0.8	0.6	<0.1	<0.1	0.9	0.6	0.9	0.1	0.2	0.1	0.4		50.0
Fe	mg/l	2.2	26	37	32	35	27	33	28	37	44	33	30	39	24	20	33	33	37	37	24	38	27	2.2	1.7	33	24	34	24	1	0.3			0.0
NO3	mg/l	9.6	<0.5	<0.5	<0.5	<0.5	< 0.5	< 0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5.9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	7.7	6.6	<0.5	<0.5	<0.5	9.5	10	10	50		1.0
TDS	mg/l	80	144	150	172	178	170	165	100	106	110	96	96	100	60	82	104	162	163	173	124	124	112	50	92	80	74	96	54	1500	1000			32.5
Cl	mg/l	9	9	10	11	11	12	11	6	11	9	11	10	9	11	9	10	9	9	11	12	11	11	7	6	9	13	9	9	250	250			0.0
Salinity	ppt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					0.0
NH4	mg/l	<0.5	3.1	1.8	2.4	2.6	1.5	2.7	2.7	2.2	2.4	2.7	2.2	2.1	2.4	<0.5	2.3	2.4	2.3	<0.5	2	1.9	2.4	<0.5	<0.5	2.4	1.9	2	<0.5					0.0
F	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	< 0.5	< 0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.5	0.6	1.5		0.0
CO3	mg/l	<1	<1	<1	<1	< 1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1					0.0
HCO3	mg/l	35	33	72	60	60	61	62	65	67	62	61	66	67	61	53	60	68	59	60	62	64	67	28	23	79	68	56	28					20.0
Na	mg/l	11	6.5	11	8.6	9	8.8	7.8	7.1	9.2	10	7.5	8.5	9.4	8.2	6.3	8.9	8.3	10	9.1	8.3	9.2	10	4.7	5	8.6	8.5	11	9.5	200	200			13.6
Ca	mg/l	11	15	11	14	11	8.8	13	14	9.2	10	9.4	8.5	13	13	14	13	12	13	12	11	9.2	14	7.7	8.1	17	14	19	10					9.1
K	mg/l	4.2	2.4	2.6	2.2	2.2	2.6	1.6	2.1	2.2	3.2	2.1	2.5	2.6	2.6	3.1	2.5	2.5	2.6	3.4	2	2.2	3.9	2.3	2.8	2.7	3.3	3.1	3.5					16.7
Al	mg/l	0.4	<0.1	<0.1	<0.1	<0.1	< 0.1	< 0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.9	1.4	<0.1	0.1	<0.1	0.5		0.2	0.2		0.0
Mg	mg/l	1	1.1	1.5	0.9	1.3	1	1.1	1.1	1.4	1.6	1.1	1.1	1.4	1	1.2	1	1.1	1.2	1.4	1	1.2	1.2	0.6	0.6	1.4	1.3	1.5	0.8	150	150			20.0
Hg	mg/l	<0.0001	<1.0	<1.0	<1.0	<1	<1	<1	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<1.0	<1.0	<1.0	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001	0.001	0.006	0.00005	0.0
Cd	mg/l	<0.0002	<0.01	<0.01	0.01	0.01	< 0.01	0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.01	0.01	<0.01	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.003	0.003	0.003	0.0004	0.0
Se	mg/l	<0.01	<0.01	<0.01	<0.01	< 0.01	< 0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01		0.0
As	mg/l	0.01	0.26	0.21	0.23	0.25	0.19	0.27	0.21	0.29	0.25	0.3	0.25	0.34	0.18	0.15	0.24	0.25	0.22	0.28	0.2	0.31	0.21	0.01	0.01	0.25	0.2	0.2	0.02	0.01	0.01	0.01	0.01	100.0
Pb	mg/l	<0.01	<0.01	<0.01	<0.01	< 0.01	< 0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.01	0.01		0.0
Cr	mg/l	<0.01	<0.01	<0.01	<0.01	< 0.01	< 0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.05		0.001	0.0
Cu	mg/l	<0.1	<0.1	<0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1	1	2	0.015	0.0
Zn	mg/l	1.9	<0.1	1	<0.1	< 0.1	< 0.1	< 0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	3	3		0.065	0.0
SO4	mg/l	10	6	<5	7	7	<5	<5	11	<5	19	<5	<5	<5	8.2	<5	11	<5	10	<5	<5	<5	<5	<5	9	5	<5	24	10	250	250			0.0
P	mg/l	<0.02	0.31	<0.02	0.05	0.37	0.02	< 0.02	0.47	0.03	<0.02	1.2	<0.02	<0.02	0.46	<0.02	0.04	0.27	1.2	0.13	2.3	<0.02	<0.02	0.7	<0.02	0.03	0.86	<0.02	1.8					0.0
Ni	mg/l	<0.1	<0.1	<0.1	<0.1	< 0.1	< 0.1	< 0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1		0.02	0.07	0.001	0.0
Ba	mg/l	<0.1	<0.1	<0.1	<0.1	< 0.1	0.1	0.3	<0.1	0.7	<0.1	<0.1	<0.1	0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	0.2	3.6	<0.1	<0.1			0.7	0.2	0.0

Table 3.6. Water quality during pumping test (abstraction), for period of 24 hours, 48 hours and 72 hours and percentage removals of chemicals at Muda River (TW1 and TW2 and upstream and downstream river) and Drinking Water Standard, Department of Standard Malaysia (DSM), (2010)

Parameter	Unit	Muda river	TW1 hours			TW2 hours			Drinking Water Standard (2010)	Percentage removals of RBF systems
			24	48	72	24	48	72		
pH		7.3	6.22	6.19	6.18	6.37	6.31	6.29	6.5-9.0	0.0
Colour	H.U.	5	5	5	5	5	5	5	15	0.0
Turbidity	N.T.U	85	10	10	10	10	10	10	5	88.2
Conductivity	µS/cm	4	101	135	161	141	135	130	-	0.0
SiO_2	mg/l	16	5.4	14.9	7.2	14.2	14.9	13.8	-	66.3
Tot. Solid	mg/l	30	95	96	102	92	99	84	-	0.0
Diss. Solid	mg/l	98	60	86	68	90	86	83	1000	38.8
HCO_3	mg/l	104	23	39	66	38	39	39	-	77.9
Cl	mg/l	24	7	1.5	0.5	1.6	1.5	0.8	250	70.8
SO_4	mg/l	9	2	1.89	1.5	2.61	1.89	3.8	250	77.8
NO_2	mg/l	1	0.02	0.46	0.01	1.12	0.46	0.75	10	98.0
NO_3	mg/l	16	0.6	0.6	0.4	0.007	0.009	0.009	10	96.3
F	mg/l	<0.5	<0.5	0.2	<0.5	0.2	0.2	0.15	0.4-0.6	0.0
P	mg/l	0	0.06	0.04	0.81	0.05	0.04	0.05	-	0.0
NH_4	mg/l	<0.5	0.5	0.5	0.5	0.71	0.86	0.86	1.5	0.0
Al	mg/l	1.2	0.2	0.65	0.1	0.63	0.65	0.78	0.2	83.3
As	mg/l	0	0.02	0.012	0.02	0.016	0.012	0.018	0.01	0.0
Ca	mg/l	16	10	11.9	13	11.3	11.9	12.63	-	37.5
Fe	mg/l	2.7	10	9.93	9.45	7.93	8.93	8.74	0.3	0.0
K	mg/l	4.5	6	3.48	5.4	3.37	3.48	3.68	-	33.3
Mg	mg/l	1.1	5.1	3.11	5.6	3.1	3.11	3.3	150	0.0
Mn	mg/l	0.2	0.9	0.95	1.2	0.59	0.62	0.65	0.1	0.0
Na	mg/l	10	4.6	3.01	5.4	2.88	2.94	3.12	200	54.0
Zn	mg/l	<0.1	<0.1	0.07	0.1	0.06	0.07	0.04	3	0.0
Cd	mg/l	<0.01	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	0.003	0.0
Co	mg/l	<0.05	<0.05	<0.05	<0.05	<0.01	<0.01	<0.01	1	0.0
Cr	mg/l	<0.01	<0.01	<0.01	<0.01	<0.03	<0.03	<0.03	0.05	0.0
Cu	mg/l	<0.01	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01	1	0.0
Hg	mg/l	<0.05	<0.05	<0.05	<0.05	<0.01	<0.01	<0.01	0.001	0.0
Ni	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.0
Pb	mg/l	<0.1	<0.1	<0.01	<0.1	<0.01	<0.01	<0.01	0.01	0.0
Se	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.0
Sr	mg/l	0.03	0.04	0.03	<0.01	0.03	0.03	0.03	-	33.3
Ag	mg/l	<0.5	<0.5	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.0
Ba	mg/l	<0.1	0.3	<0.01	0.2	<0.05	<0.05	<0.05	0.7	0.0
Carbonate Hardness	mg/l	110	26	42.4	56	39	42.4	44	500	76.4

Quality characteristics of water extracted during the pumping test

Cryptosporidium parvum is some enteric and obligate protozoa, which infects the gastrointestinal tract of animals and humans, causing cryptosporidiosis. However, the oocyst stage is the one of concern due to its resistance to conventional water treatment methods, its prolonged survival and its low infectious dose (as low as 1.0-10.0 oocysts per individual), and because it is the propagation phase commonly found in the environment and causes gastroenteritis, mostly to young and immune compromised adults. The most frequent route of transmission is the oral-faecal route, and human and animal faeces are the common source of contamination. Farizawati et al. (2005) reported a study of Cryptosporidium and Giardia from cattle farms located near Langat and Semenyih river showed that out of 24 samples of water taken from Semenyih river, 4.2% was positive for Giardia cysts with a concentration of 1.3 cysts/l and 20.8% were positive with Cryptosporidium oocysts with a range of 0.7–2.7 oocysts/l. In Langat River, from the 43 samples taken, 23.3% were positive for Giardia cysts with a range of 1.5–9.0 cysts/l whereas 11.6% were positive with Cryptosporidium oocysts with a range of 2.5–240.0 oocysts/l. This shows that wastewater was discharged into the river signifying contamination of (oo)cycts from the cattle farms into the river system. The water samples were collected during the pumping test with intervals of 0.5, 24, 48, and 72 hours to analyze the presence of microorganism. Analysis results of water samples from the Langat river and DW2 show that the samples from the river contained *Giardia* cyst with a concentration between 0.1 and 2.9 cysts/L (Shamsuddin et al 2014), whereas the well water had no cysts. However, no reported disease outbreak in relation to water borne giardiasis has been reported in the country. *Giardia* cyst can be eliminated at temperatures greater than 65 °C. Moreover, conventional chlorine concentrations used for water treatment could not kill *Giardia* cyst. Although ozonation is effective, it is expensive. For analysis of *Cryptosporidium and Giardia and E.coli* concentrations in the Riverbank of Langat River and eight numbers of samples were collected. One sample from upstream (S1), confluence of Langat-Semenyih River and downstream (S3) of Langat River within the study area, and two samples was collected from the tube well (TW1 and TW2). Three (3) samples were collected from pond A, B and C. The analysis used USEPA method 1623 (USEPA, 2005) was used for testing purposes. Total coliform and E. coli concentrations were determined using the most-probable number (MPN) method from Colilert™ at NAHRIM Laboratory. E.coli is bacteria found in the intestines of humans and many animals in which it is generally harmless / threaten health. However, on the other limb, E.coli can cause serious diseases such as infections of the urinary system, the problem of diarrhea and infection of the lining of the brain (WHO 2011). E.coli maximum content authorized for drinking water quality standards for the Department of Standards Malaysia (2010) for the raw water is 5000 MPN/100ml, while for the treated water is 0 MPN/100 ml. Standards for the WHO (2011) also is 0 MPN/100 ml. E. coli is a thermo-tolerant coliform bacterium that causes gastrointestinal infections.It has a low dose of infection (10-100 cells per individual) and has a good resistance to acidic conditions. Although its origin is human and animal faeces, it is a very cosmopolitan bacterium that can be found in insects, food, vegetables, and water. It can be easily transmitted via person-to-person contact (Campbell and Wallis 2002). Its consistently presence in warm-blooded animal faeces and its easy and quick detection, makes it one of the preferred indicators for faecal contamination. The analysis showed that the content of Cryptosporidium and Giardia (Langat) in the river water is very high compared to the groundwater. Generally, surface water such as river water more easily contaminated by pathogenic microorganisms that are caused by human activities and animal waste mainly from urban waste and faeces of humans and animals (Schmidt et al., 2003). Elimination of microorganisms in groundwater because the possibility of microbiology and screening process as well as the impact of the movement of water within the river into the groundwater (Abdel-Lah and Shamrukh 2006; Schijven et al.,

2002).For analysis of for total coliform, fecal coliform and E. coli concentrations in the Jenderam Hilir, Selangor, and 8 samples were collected. One sample from upstream (S1), confluence of Langat-Semenyih River and downstream (S3) of Langat River within the study area, and two samples was collected from the tube well (TW1 and TW2). Three (3) samples were collected from pond A, B and C. The result of this study showed that samples in the water taken from Langat River were positive for total coliform, fecal coliform and E. coli. Total coliforms, fecal coliform and E. coli were not detected in groundwater (TW1 and TW2) samples. For analysis for E.coli on groundwater in Linggi riverbank area, 36 samples tested showed the not presence of E.coli, from monitoring wells. For samples of river water, all 6 samples containing E.coli with the range between 17,800 MPN/100 ml to 29.667 MPN/100 ml, with an average of 22,866.6 MPN/100 ml. For analysis for E. coli on groundwater and surfacewater in Muda area, 24 samples tested also showed not detected presence of *E. coli*, from test well and piezometer wells. For samples of river water, all 5 samples containing *E.coli* with the range between 12,400 MPN/100 ml to 20000 MPN/100 ml.

Conclusions

This study was inspired by the climate change were impact of three sites of pilot project with different geological characterictics located at the lower portion of the heavily populated Langat river basin, Linggi river basin and Muda river Basin water crisis, for which conjunctive use of surfacewater and groundwater will combine using Riverbank filtration (RBF) was considered as a potential solution. Higher incidences of pollution to the rivers in Malaysia has lead to the decrease in resources for drinking water. The closure of water intakes and water treatment plants has impact on water supply, and thus, on economic activities for industries and other sectors. At the same time, many developing countries like Malaysia, are faced with a big challenge to provide safe drinking water to the ever-increasing population. Currently, the treatment of river water uses chemicals to reduce several contaminants due to pollution. The chemical contents could give long term effects to the health of the consumers. However, there is hope in a more effective, but low-cost technology. RBF is a natural process using natural soil (aquifer) to treat river water and at the same time utilizes groundwater. Moreover, due to its ability to remove even the most persistent contaminants and microbes, RBF can enhance treatment steps in a water treatment facility, especially in a conventional water treatment. RBF is a method that has long been known but it is still new and has not been practiced in Malaysia. Nevertheless, RBF is site specific and requires thorough site investigations to assess its feasibility based on the local site characteristics. Therefore, this research was carried out to fill some of the knowledge gaps regarding the conjuctive use groundwater and surfacewater using RBF system. For that reason, geophysical data, sieve (particle size) analysis, pumping test data and water quality data techniques were employed to carry out the research. First, in early stage of the investigation, geoelectric resistivity was performed to determine the suitability of the geology and the hydrogeological characteristics of the study area to establishment of RBF sites. Based on geophysical result, piezometer and test wells were drilled and develop and pumping test was conducted to determine the factors and processes controlling the groundwater and surfacewater interaction. The result suggested that the setting of the river channel, which is connected to an alluvial aquifer in the area, is hydraulically are the dominants factor controlling the interaction between groundwater and surfacewater of the RBF systems. The RBF could be managed under the conjunctive use of the surface and groundwater of the area. Similarly, geology characteristic resulted the increasing of water quantity, reduced pollution and water quality are the principal factors affecting the aquifer and water abstracted from wells adjacent to the river is predominantly surface water, where the surface water recharges the regional groundwater. The

thickness of the aquifer located below the river channel is more than 5 m, and consists of more than 80% gravely sand (Langat river), 80 % fine sand (Linggi River) and silty sand 80% (multiple layer of sand at Muda River alluvial aquifer) with high hydraulic conductivity (K) and transsimivity (T) values. In addition, based on the constant pumping test for one of the wells, the yield was as much as 128 m^3/hr (3.072 million litres per day) with a drawdown of only 2.63 m for Langat Riverbank. However different with Linggi River Basin because the materials of aquifer are fine sand rather than Langat and Muda River. Pumping tests at the Linggi Riverbank, which comprised of the constant discharge tests for the SL-TW2 test wells for determining the aquifer characteristics was conducted. Pumped for 72 h at the rate of 17.1 m^3/h and the final drawdown was 7.24 m, while the total drawdown was 5.65 m was measured. These results showed that the test well had a hydraulic conductivity of 17.1 m/day, while the monitoring wells showed a hydraulic conductivity ranging between 54.1-63.1 m/day, with a mean value of 53.1 m/day. The test well showed a transmissivity value of 102 m^2/day, which ranged between 325 - 379 m^2/day for the monitoring wells, with an average of 319 m^2/day. The distance between the production well/s and the river is one of the significant factors that influence the reduction of water contaminants from the river. The study had shown positive effects on the quality of infiltrating water. Specifically, a reduction of 75-98% was observed in turbidity, NO_3-, Cl-, SO_4^{2-}, NO3-, and Al^{3+} concentrations. However, water samples from the test wells during pumping showed higher concentrations of Fe^{2+} and Mn^{2+} because of redox reactions. For microorganisms such as *E. Coli*, total coliform and *Giardia* and *Cryptosporidium*, the removal efficiency was 99.9%. All water quality parameters measured fell below the allowable limits for potable water. The sustainability of the quality of extracted water in the long run should be further monitored. The conclusions about the removal processes related to water chemistry (to explain the filtration effect on water quality in the long term) has remained tentative because the water samples analysed were only based on a 72-hour (maximum) pumping test. The quality of conjunctive use groundwater and surfacewater using RBF systems is mainly dependent on the aquifer`s material type, material quantity, and quality of infiltrating surface water from the Langat River, Linggi River and Muda River.

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ANALYSIS OF TRANSPORT AND ACCUMULATION OF SEDIMENT FOR UPPER SKUDAI RIVER CATCHMENT

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Abstract

For decades, sediment loads have been extensively investigated as a primary indication of water quality standards in natural systems. The Hydrological Simulation Program-Fortran (HSPF) model was applied to the Skudai River watershed, located in southern of Johor, draining from Sedenak to Johor Bahru within 293.7 km2. The meteorological data to the model were obtained from Department of Irrigation and Drainage Malaysia. Significant land cover changes have occurred in Skudai watershed that contributes sediment transport and deposition to the upper Skudai River in Johor. To model moderate mixed land used watersheds, a shorter simulation such as hourly data to represents the dynamics of sediments in Skudai river The purpose of this study is to evaluate sediment accumulation and transport using USLE to analyse suspended solids by assigning HSPF parameters to adjust sensitivity analysis for calibration and validation from 1 March 2012 to 15 May 2012 and 5 November 2013 to 5 February 2014 respectively. The Coefficient of Determination and Nash-Sutcliffe Efficiency coefficients of calibrated flows, perform better compared to validation model for hourly and daily simulation. Daily R2 and NS statistics were good in Skudai watershed and fair in hourly time period. The model performance was more notably better during the normal or baseflow hourly period in comparison to the observed data.

Keywords: USLE, HSPF, Sediment simulation, Skudai River.

Introduction

Suspended solids mainly from soil losses transport into the river has been recognized as a significant source of surface water problems since many years. Soil losses associated with a response of hydrological processes, which are primarily affected by topography, soil, climate, and most important land use characteristics of the area. Land use characteristics are significantly related to water balance even though climate conditions are generally most significant in some cases. A main issue facing watershed researchers is how land use and management ties to the quality at the river basin outlet. Rapid and unpredictable fluctuations of suspended solids concentrations related to anthropogenic causes or during natural hydrologic events were identified as difficult to characterize suspended solids transport in rivers (Susfalk et al., 2008). The almost impact of suspended solids concentration to the river was increase low visibility through the water column with the degradation of fish habitat and decrease of dissolved oxygen to the river (Moltz, H et al., 2010b). Wischmeier and Smith (1978) were discussed available erosion and sediment discharge prevailing stream water quality changes and usually linked to land uses within a watershed. Since unmanaged of sediment discharge mainly from suspended solids due to land use changes are main contribution of water quality, a suitable models must be selected to performed well assessment for mixed land use watershed. Recent watershed models were used to identify and

better understanding between land use activities and water quality process occurring within a watershed. Many models were used several mathematical equations to characterize various surface and subsurface even groundwater distribution for sediment accumulation and transport processes both on a hill slope and in the stream during continuous or single rainfall event. Among various existing watershed models, Hydrological Simulation Program-Fortran (HSPF) is the one of relatively high watershed models have been used to simulate continuous and lumped-parameter model transforming long time series of rainfall and evapotranspiration data into time series of stream-flows using continuous accounting of soil moisture levels. A set of pervious and impervious unit areas and a set of streams, reservoirs or reaches are descriptively represented at this watershed model simulation (Shenk et al., 2012).

Method

The Skudai Watershed flows from Sedenak to Johor Bahru with a wide variety of land covers (Figure 1). The watershed topography is undulating with steeper foothill of intermediate height ranging from 80 meter to 100 meter flanking the western and eastern of an area. The highest level of 100 meter and above is located at the northern at the river catchments boundary. Land use classifications were grouped into four categories: Forest, Agricultural, Urban/Built Upland and Barren. Land use is 50.9% agricultural, 41.8% urban/built upland, 4.7% forest and 2.6% barren. The slope of the watershed area ranges from 0.1 to 2% with an average slope 0.48%. Typically, the average annual rainfall within this area is 2000 mm and total stream length is 46.5 km. Daily temperature ranges from a maximum 32 ºC to 22 ºC. Soils texture of the watershed belongs to the coarse-grained soils of the sedentary soils of Rengam-Jerangau formation and vary texturally from sandy loam clay to sandy clay respectively in depth. Spatial and temporal dataset including topography, land use, soil properties, reach characteristics, extensive meteorological data were established using BASINS/HSPF Map Window interface. The elevation data used in this model was provided by Consortium for Spatial Information (CGIAR CSI), SRTM 90m Digital Elevation Database version 4.1 (SRTM 90m,2012). The Shuttle Radar Topography Mission (SRTM) was used to delineate Skudai Watershed and generate sub-catchments to establish associated reach network for Skudai River. By using toolkits provided by BASINS, all geoprocessing were performed and land cover with topographical data were overlaid to export HSPF User Control Input file (UCI). The control file specifies for a Skudai Watershed a set of parameter values to be used and an establishment of tabular characterization of stream geometry (F-TABLE). F-TABLE provides an area, volume, and streamflow river cross section for Kampung Pertanian site study. Precipitation, potential evapotranspiration, mean temperature, streamflow and observed total sediment concentrations data were processed in Watershed Data Management (WDMUtil) and then incorporated into the watershed data management (.wdm) file developed for the simulation. These data, on average were measured on an hourly time basis at the Kampung Pertanian station and were distributed to the UCI file.

Kampung Pertanian station is deployed an equipment to estimating sediment characteristics and total suspended solids. The site is equipped with ISCO 6712 an in-stream portable sampler and all data from the bottles were collected hourly (Teledyne ISCO, 2012) and the process of sampling are described as Figure 2. During the preliminary year of sampling, water samples for Total Suspended Solids (TSS) analysis was collected every day, resulting in an average 24 samples per site. Following the first year of monitoring, all data were evaluated to determine an appropriate number and TSS range of samples needed to establish rating curve relationship between TSS and turbidity. Rating curve was done to minimize costs and reduce the number of samples collected during base flow and after collection, samples were analysed in the laboratory within 24 hours (Walling, D. E., 1977).

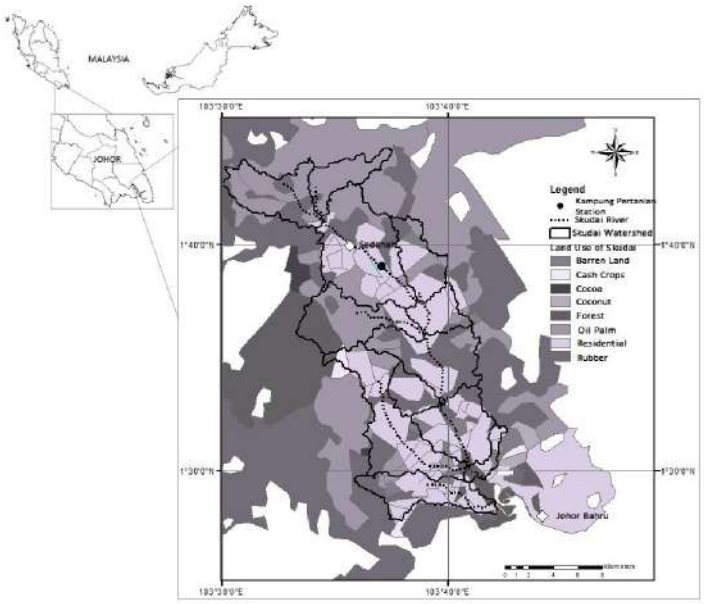


Figure 1. The Skudai river and its tributaries



Figure 2. Sampling processes at Kampung Pertanian Station to collect suspended sediment

Estimating Sediment Loadings from the Land Use

The key steps in modelling sediment erosion with HSPF are loads calculation by land use within each watershed (USEPA, 2006). The TMDL Universal Soil Loss equation (USLE) is an empirical model that estimates average annual soil loss caused by sheet or rill erosion from hill slope element. TMDL USLE usually use as distribution of sediment movement within certain area but does not account the amount of sediment wash-off into drainage system (Sams III, 1995). The TMDL USLE formulation is express as follows in Equation 1:

Estimating Sediment Loadings from the Land Use

A = R*K*L*S*C*P (Equation 1)

A = Annual soil loss in tons per acre per year

R = Rainfall erosivity factor

K = Soil erodibility factor

L = Slope length factor

S = Slope gradient factor

C = Cover management factor

P = Erosion control practice factor

The R factor is obtained from regional Department of Drainage Malaysia (DID) which is accounted from amount of rainfall intensity at Kluang, Johor and indicated approximately as 345.5 MJ mm/ha h yr. The K factor was developed from erodibility nomograph based on clay, silt, sand, organic matter, soil structure and permeability and for Skudai Watershed is 0.18. For L and S factors, values were dependent upon factors such as slope gradient factors and length of slope for each sub-catchments. Considering these elements there were range 0.1 to 1 for combination both of them respectively. The relative effectiveness of soil and crop management system or vegetation in terms of preventing soil loss typically related to C and the ratio of soil loss by a support practice to that of straight-row farming up and down the slope is consider as P factor. The values for both factors were range from 0.15 to 1 depending on various land use in Skudai Watershed.

Total soil erosion estimated by TMDL USLE model is shown in Table 1 and results indicate that agricultural land consists rubber and palm oil plantations produced the highest erosion values with 0.16 ton/acre/month. Since sediment calibration and validation were performed in hourly time period and data limitation, sediment target of loading for each land use were estimate in monthly. The estimated sediment target is then compared with HSPF model to ascribe which parameters were really need to be concern. Table 2 depicts calibrated soil erosion parameters for production and reduction of detached sediment on pervious land throughout the calibration. Simulation of scouring process in pervious land areas was used by HSPF to determine sediment form streambanks since it does not include the process of bank erosion (Senior, L.A, 2003a). The parameters were include Supporting Management Practice (SMPF), exponent in the soil detachment equation (JRER), coefficient in the soil detachment equation (KRER) and fraction by which detached sediment storage decreases each day during non storm periods (AFFIX). Other parameters adjusted during calibration were sediment removal from pervious land by wash off erosion process. They involved of coefficient in the wash off or transport equation (KSER) and exponent in the soil wash off equation (JSER). It was found JRER, AFFIX and JSER have been reduced the total simulated soil erosion if these parameter values were increased. Increasing the value for JSER substantially decreased sediment washoff and increasing AFFIX was decrease re-attachment of soil during its overland transport.

Table 1: Land use with specific sediment target of loadings from USLE TMDL Tool

Land Use	USLE tool edge of stream load (ton/ac/month)	Area (Acre)
Forest	0.0194	75.4
Rubber	0.16	2553.4
Residential	0.0757	3345.9
Oil Palm	0.16	7044

Table 2. Parameter values for sediment erosion simulation for the Skudai river watershed

	Parameter	Calibrated Value	Typical Value
SMPF	The supporting management practice	0.1-1.0	0-1
JRER	The exponent in the soil detachment equation	0.19-0.45	0.15-0.45
KRER	The coefficient in the soil detachment equation	2.45-2.5	1.5-2.5
AFFIX	The fraction by which detached sediment storage decreases each day during non storm periods	0.1	0.03-0.1
KSER	The coefficient in the wash off or transport equation	0.5-5.0	0.5-5.0
JSER	The exponent in the soil wash off equation	1.6-2.5	1.5-2.5

Estimating Sediment Loadings from the Land Use

Several different numerical criteria were used to evaluate the simulated with observed data. They are follows the Nash-Sutcliffe coefficient (E_{NS}), the root mean square error (RMSE), the coefficient of determination (R^2) and the mean relative error (RE) and these statistics were used on the basis of the ASCE recommendations (1993). The Nash-Sutcliffe coefficient E_{Ns} was expressed as (Equation 2):

$$E_{NS} = 1 - \frac{\sum_{i=1}^{N}(O_i - S_i)^2}{\sum_{i=1}^{N}(O_i - O_{Avg})^2} \qquad \text{(Equation 2)}$$

Where O_i is the ith observed value, O_{Avg} is the mean of the observed values, Si is the i_{th} simulated value, and N is the total number of events. E_{NS} can range from negative to infinity to 1, with 1 denoting a perfect agreement with observed data. Nash-Sutcliffe efficiency has been used in many researchers to determine model evaluation and considered as one of the best statistics for evaluation of continuous hydrograph simulation programs (ASCE, 1993). The coefficient of determination R^2 represents the fraction of variability in y which can be explained in variability of x. It ranges from zero to 1, with 1 is the perfect agreement between simulated and observed data and it was given by (Equation 3):

$$R^2 = \left\{ \frac{\sum_{j=1}^{n}(O_j - \bar{O})(S_j - \bar{S})}{\left[\sum_{j=1}^{n}(O_j - \bar{O})^2\right]^{0.5}\left[\sum_{j=1}^{n}(S_j - \bar{S})^2\right]^{0.5}} \right\}^2 \qquad \text{(Equation 3)}$$

Where O_j is the observed flow at time step j, $\bar{O}$ is the average observed flow during the simulation period, S_j is the model-simulated flow at time step j and $\hat{S}$ is the average simualted flow at time step j and for the relative error (D_v) was calculated as (Equation 4):

$$D_v(\%) = \frac{X_m - X_s}{X_m} \times 100 \qquad \text{(Equation 4)}$$

Where X_m is the observed total runoff volume and X_s is the model-simulated total runoff. The smaller the number of D_v gives the better result for simulation and observation data. For a perfect model, D_v would be equal to zero.

In-stream sediment calibration

For Skudai Watershed, the simulation of erosion and sediment accumulation to the river were begin after hydrologic simulation since simulated flow values were closely matched with surface runoff for pervious and impervious land to transport and deposit sedimentation. Sediment deposition involves sediment loading rates in land surface simulation and precede before in-stream sediment calibration. In-stream sediment calibration focuses on the channel process mainly involve deposition, scour and transport. These processes were determined both of total sediment load integrated with outflow sediment concentration that wil be compared with observations data. To calculate the capacity of river to transport sand, toffaleti method has been choosen to this study. The results of calibration concurrently with observed hourly suspended data are presented in Figure 3. An overall relative errors of calibrated sediment load to the observed values are -6.99 and 235.26 for hourly and daily respectively. Based on the Nash-Sutcliffe (NS) coefficient of simulated sediment load (Table 3), the HSPF model performed better in hourly compare to daily time period but for coefficient of determination (R^2) it may seem contradictory to hourly period. Statistically, the NS and R2 values for hourly are 0.87 and 0.667 respectively whereas 0.61 and 0.797 for the daily time period.

It is clear that the model underestimated with low value by around twice the observed data. This lack of surface runoff can partially explain the low values of the sediment loads model computed by HSPF. From this calibration, scour process is not simulated accordingly since the low resolution Digital Elevation Model (DEM) data has been used. Generally, HSPF abstracted a length and stream elevation from upstream to downstream using DEM data. Hence, higher resolution gives detailed elevation and stream length, therefore to extend this study afterwards, higher DEM resolution data such as DEM 30 meter must be use.

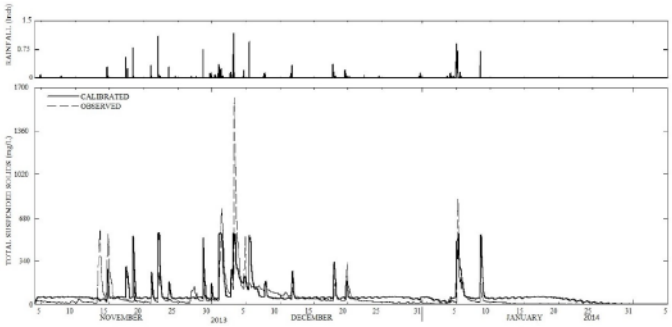


Figure 3. Comparison of calibrated versus observed total suspended sediment concentration at Kampung Pertanian of the Skudai River Basin

Table 3. Model evaluation of suspended solids for calibration period

Statistic	Hourly SS	Daily SS
RE (%)	-6.99	35.26
R^2	0.667	0.797
NS	0.87	0.61

In-stream sediment validation

The validation process was conducted with sediment load data for the period between 1 March 2012 and 15 May 2012. Statistical evaluation of HSPF validation results on hourly and daily were found at Table 4 and validation concurrently with observed hourly suspended data are presented in Figure 4. Validated and observed daily sediment load showed better values for R2 and NS, however hourly values showed less than that. R2 value for hourly period was 0.634, lower than the one computed for daily basis 0.815. Moreover, the NS value of 0.589 indicated that the daily basis was a better than hourly NS value -0.195 and relative error showed the same trends with values varied from -65.24% to 42.84%. Based on results, daily basis did a good performance in modelling suspended sediments loads in the Skudai watershed for long term daily intervals and HSPF tends to not accurately simulate hourly since various parameters needs to be considered. Most of parameters included on HSPF are not represent detailed in literature reviews and by assuming parameters contribute a lower precision on TSS simulation on hourly simulation.

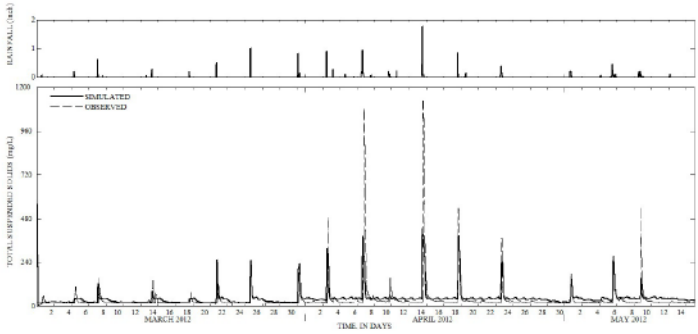


Figure 4. Comparison of validated versus observed total suspended sediment concentration at Kampung Pertanian of the Skudai River Basin

Table 4. Model evaluation of suspended solids for validation period

Statistic	Hourly SS	Daily SS
RE (%)	-65.24	42.84
R^2	0.634	0.815
NS	-0.195	0.589

Conclusions

The Skudai watershed drains 293.7 km^2 from Kluang to Johor Bahru district and is used for major assessment to rehabilate Johor Straits in future. Monitoring data indicate that water quality especially sediment accumulation is impaired and does not support designated uses of the river. Based on hourly results, suspended sediment are difficult to interpret due to the sparse of missing and coarse DEM data. The coefficient of determination and Nash-Sutcliffe efficiency coefficients of calibrated flows, perform better in the calibration model compared to validation model for hourly and daily. Daily R^2 and NS statistics were good in Skudai watershed and fair in hourly time period. The model performance was more notably better during the normal or baseflow hourly period in comparison to the observed data and have a significant impact to the water quality simulation. The simulation sediments of calibration was compared statistically and the overall relative errors of simulated sediments to the observed are -6.99 and 35.26 for hourly and daily respectively and the relative errors of validation for hourly and daily are -65.24 and 42.84 respectively. These findings assist in improving model acuracy and improve the models ability to predict larger watersheds with different land use changes. Results from this study are significant at the scale of the watershed with rapid suspended sediment concentrations, however study using more long term observed data is needed to determine which process are more dominant whether scour and deposition process.

Acknowledgements

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GROUNDWATER QUALITY ASSESSMENT IN SMALL ISLAND AQUIFER, MABUL ISLAND, SABAH

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Abstract

Mabul Island depend mostly on groundwater as a major source of water supply for domestic and tourism industry purposes. There was no inflow from river and the highest level was 4.2 meter above mean sea level. Rainwater is the only source of recharging the groundwater to sustain the quality. Over-abstraction of fresh groundwater lens leads to saltwater intrusion and deterioration of its quality. This study aimed to assess and understand the groundwater characteristics in the fragile aquifer of the island. In order to assess this issues, a groundwater sampling was collected 4 times between March 2018 to October 2019 from 15 dug wells scatter in the island. The geochemistry concentration of chloride and electrical conductivity usually used to determine saltwater intrusion. This study focuses on the assessment of freshwater lens mixing and salinization. The mixing fresh groundwater lens situated from 2.5 to 2.9meter depth below ground level (bgl) which quality defer from 1,218 to 23,170 µS. Depth below than 4 meter from ground level is considered as seawater. Most of the groundwater pumping wells came from the tourism industry and were not used for a drinking purposes. Most of the groundwater was identified as saline water and only a part of the island shows slightly saline water based on the ionic strength and chloride concentration. Based on the analysis of groundwater lens quality and density dependent flow model indicate that the island's coastal aquifer has been encroached by seawater. Extensive research is currently being carried out worldwide in order to understand the mechanisms of SI and develop strategies to control the process. For example, costly technological solutions, such as desalination, barriers or injection wells have been implemented to deal with the reduction in freshwater availability. Consideration for this technologies factor affecting saltwater and freshwater interface.

Keywords: Saltwater intrusion, Groundwater Lens, Geochemistry, Chloride, Ionic Strength

Introduction

The development of groundwater resources in oceanic islands and mainland coastal areas are a delicate issue and careful management is required if water quality degradation due to the encroachment of sea water is to be avoided. In many cases, difficulties arise when aquifers are pumped beyond their natural recharge rate and sea water is drawn into the system. Problems can also occur when excessive pumping at individual wells lowers the potentiometric surface on a localized scale and causes upconing of the natural interface between fresh water and saline water. Coastal and island aquifers are also sensitive to sea level changes such as postulated rises due to global warming. The associated volumetric expansion of sea water and melting of snow caps would increase the extent of sea water intrusion and reduce the availability of fresh groundwater resources.

Saltwater intrusion is a major concern commonly found in coastal aquifers around the world. Saltwater intrusion is the induced flow of

seawater into freshwater aquifers primarily caused by groundwater development near the coast (Falkland,1993). Where groundwater is being pumped from aquifers that are in hydraulic connection with the sea, induced gradients may cause the migration of salt water from the sea toward a well, making the freshwater well unusable. Because fresh water is less dense than salt water it floats on top. The boundary between saltwater and freshwater is not distinct; the zone of dispersion, transition zone, or saltwater interface is brackish with saltwater and freshwater mixing.

Under normal conditions fresh water flows from inland aquifers and recharge areas to coastal discharge areas to the sea. In general, groundwater flows from areas with higher groundwater levels (hydraulic head) to areas with lower groundwater levels. This natural movement of fresh water towards the sea prevents salt water from entering freshwater coastal aquifers (Barlow, 2003). Groundwater pumping/development can decrease the amount of fresh water flowing towards the coastal discharge areas, allowing salt water to be drawn into the fresh water zones of coastal aquifers. Therefore, the amount of fresh water stored in the aquifers is decreased (Barlow, 2003).

This unfavourable situation caused a great concern to peoples living island. This is because of seawater intrude toward inland will lead to saltwater intrusion into coastal aquifer that contaminate the freshwater supply (Priyanka & Mahesha, 2015). Contamination of 2 – 3% of saltwater into coastal aquifer will increase the waters salinity and resulting in water quality degradation (Abd-Elhamid & Javadi, 2011). The problem also experienced by villagers living in the area of this study. Most of the residents used groundwater withdrawn from the dug wells. Mabul Island depends entirely on groundwater and rainwater resources for basic uses such as for watering crops and washing clothes. In some parts of the island, the current rate of groundwater extraction is depleting the resource faster than it is being recharged (Idris, et. al., 2014). In conjunction to this problem, a study is carried out to confirm the major sources of groundwater quality pollutants based on sampling wells that located scattered in the island to assess the concentration of saltwater intrusion into the wells.

Material and Methods

Mabul Island, Sabah is approximately about 0.4 km² in area and is classified as a small island. Indeed, approximately 90% of the area is covered by coastal sediment sand and developed for tourism activities. Samplings were carried out at 15 private wells, scattered in the island (March 2018, October 2018, March 2019 and October 2019). Samplings were conducted by performing in situ measurements of selected water quality parameters such as electrical conductivity (EC), total dissolve solid (TDS), salinity, pH and turbidity. The villages involved for which geochemistry data were samples included Kg. Mabul, Kg. Rama-Rama and Kg. Tengah. The locations of sampling point are shown in Figure 1.

Groundwater were sample using polyethylene bottles based on the methods described in APHA (2005). In-situ analyses were conducted in the field using multiparameter sonde YSI 6600 for the Electrical Conductivity (EC), pH, dissolved oxygen (DO), redox potential and temperature. Major cations (Ca2+, Na+, Mg2+ and K+) were determined using inductively coupled plasma mass spectrometry (ICP-MS) model Nexion 300X, made by PerkinElmer from United State of America (USA) according to the Environmental Protection Agency (EPA). Major anions and all analyses were performed in the water quality laboratory and follow the procedures referred to APPA (2005).

a)



b)



Figure 1. a) Study area and b) public wells sampling location

Results and Discussion

Major anions and cations, pH, conductivity, total dissolved solids, as well as the temperature and colour were assessed on all samples collected. The results show that: pH range is 6.71 - 9.94, conductivity between 510 -15,650 µS/cm (25 °C), TDS range 360 - 11,141 mg/L and chloride concentration ranges from 2000 - 10889 mg/L. More than 86% of samples, Cl- concentration exceeded the WHO (1984) value for standard drinking water (250 mg/L) and in 66% of samples, Cl- concentration exceeded the WHO (1984) highest admissible concentration (600 mg/L). This high Cl- concentration is due to mixing with seawater. Minimum and maximum of water quality parameter results are summarised in Table 1.

All geological environments may contain naturally occurring saline water resulting from geochemical processes within each geological setting. Naturally, highly saline waters typically have Cl- as the dominant anion and Na+ as the dominant cation.

Sodium and Chloride concentration in 15 dug well shows that well W7, W8 W12 and W13

has the lowest values (Figure 2). The is because the wells are located at the center of the island and villagers use buckets to draw water from these well and not a centrifugal pump

Table 1. Summary of water quality parameter (min-max) of groundwater.

	W1		W2		W3		W4		W5		W6		W7		W8		W9		W10		W11		W12		W13		W14		W15	
Parameter	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Min	Max	Min	Max	Min	Max	Min	Max	Min	Min	Max	Min	Max	Min	Max	Min	Max	Min	Min
pH	7.4	8.1	7.3	7.6	7.1	7.3	7.2	7.5	7.1	7.8	7.1	7.4	7.4	7.4	7.3	7.6	7.1	7.3	7.2	7.5	7.5	7.7	7.1	7.4	7.1	7.4	7.3	7.5	7.0	7.3
Alkalinity	183.0	318.3	186.0	259.0	235.0	458.6	230.0	314.0	162.0	256.0	254.8	299.0	228.8	297.0	171.2	395.0	142.3	319.0	244.2	278.0	211.0	247.0	154.8	371.0	192.3	280.0	291.3	341.0	269.2	373.0
Conductivity	2908.0	9995.0	2695.0	15746.0	6565.0	12915.0	4520.0	23481.0	5377.0	11310.0	4314.0	6703.0	1629.0	11506.0	1218.0	2809.0	3429.0	3811.0	2198.0	2688.0	1994.0	5737.0	1302.0	5766.0	1755.0	4157.0	8448.0	18070.0	12480.0	24732.0
Calcium	86.8	204.0	88.9	260.0	210.5	317.6	178.1	234.0	129.0	283.0	187.0	267.7	115.0	252.0	102.2	141.0	192.0	276.9	148.0	174.8	114.1	152.0	129.5	207.0	154.0	193.3	192.7	287.7	305.3	371.4
Magnesium	81.0	259.0	100.6	374.0	135.0	565.2	84.0	249.8	120.0	456.3	79.0	200.8	35.9	316.0	22.8	63.0	56.0	139.1	40.0	71.2	86.0	191.5	28.5	96.0	43.7	90.0	321.0	722.5	454.7	1710.3
Sodium	661.0	2484.0	813.4	3777.0	1051.0	5293.7	775.0	2221.5	1258.0	4010.2	684.0	1798.4	254.4	2989.0	140.7	560.0	533.0	1058.3	324.0	535.8	728.0	1619.4	196.5	962.0	329.9	922.0	2995.0	6246.2	4040.4	15960.2
Potassium	27.0	80.0	27.6	128.0	49.0	128.8	39.0	77.0	48.0	113.1	36.0	61.0	12.7	95.0	8.1	24.0	38.0	53.5	30.0	59.6	27.0	49.7	11.9	39.0	20.9	35.0	90.0	184.0	105.9	289.8
Chloride	837.4	4976.0	820.6	9332.0	2070.0	5649.0	1360.0	3237.0	1937.1	6200.0	1154.9	3910.0	433.1	5518.0	240.0	645.0	771.3	3860.0	402.6	775.0	1278.6	2435.0	224.0	1419.0	361.5	1474.0	2854.0	9120.0	5480.0	10889.0
Fluoride	0.2	0.4	0.3	0.5	0.0	0.5	0.3	0.4	0.1	0.5	0.3	0.3	0.0	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.2	0.3	0.3	0.4	0.1	0.1	0.0	0.1	0.0	0.3
Nitrate	9.4	22.5	43.0	94.0	122.1	299.0	190.4	238.0	85.0	139.8	134.0	160.5	1.2	75.8	19.0	106.0	308.0	574.0	153.0	270.9	7.7	20.0	70.7	192.0	115.0	225.7	19.4	33.5	0.2	3.0
Sulfate	71.0	528.0	143.6	667.0	318.0	750.0	194.0	417.0	277.0	602.0	217.7	370.0	77.5	605.0	53.4	134.0	194.0	221.0	133.0	176.0	141.0	296.0	53.5	251.0	67.7	207.0	412.8	1160.0	523.0	1333.0
Iron	0.1	0.5	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.1	0.3	0.0	0.3	0.0	0.3	0.1	1.9
Manganese	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zinc	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1

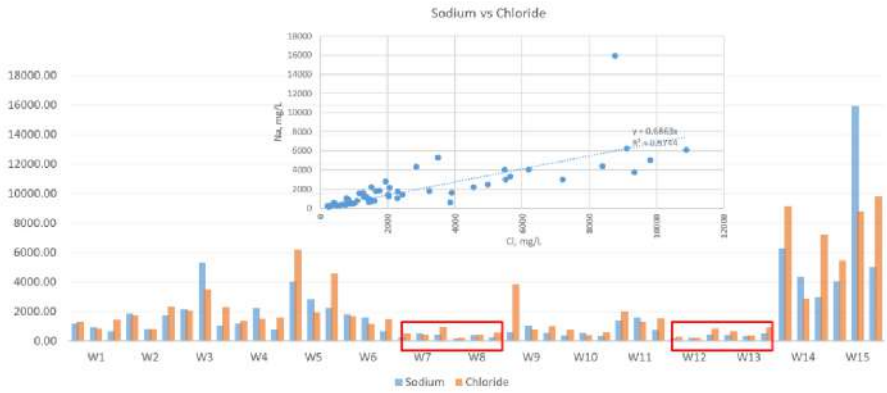


Figure 2. Sodium and chloride concentration from 15 dug wells

Classification of hydrochemical facies for groundwater according to Piper diagram is shown in Figure 3. Although various hydrochemical facies were observed, NaCl type is dominant. Large proportions of the groundwater show NaCl type, which generally indicates a strong seawater influence (Pulido-Leboeuf, 2004) or upconing of saltwater, while CaCl water type is indicating salinization and cation exchange reaction (Walraevens & Van Camp, 2005).

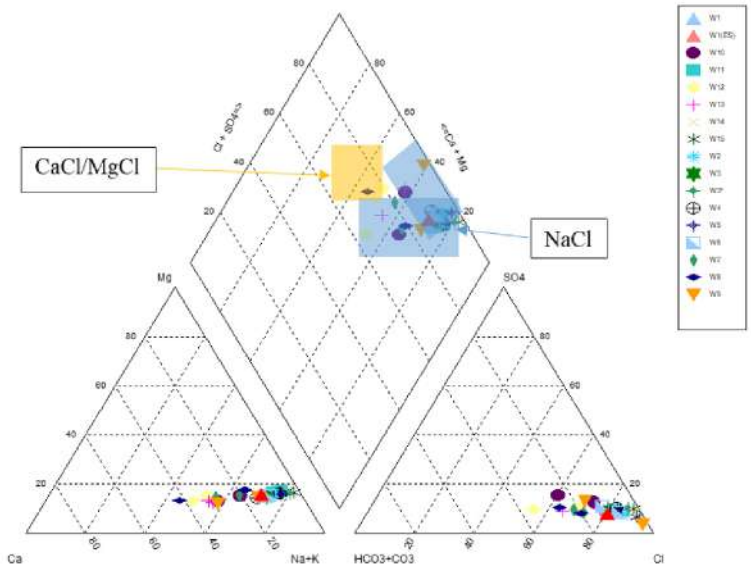


Figure 3. Water types in Mabul Island according to piper diagram were CaCl/MgCl and NaCl. (after Nawal, et. al., 2011)

Figure 4 shows the composition of salt ions vs selected wells (W1, W8 and W15). These well which has low to high concentration of Chloride. The salt component of W8 which has more Calcium (19%) and less Chloride (38%) than W1 (Ca2+ - 6%; Cl- - 43%) and W15 (Ca2+ - 3%; Cl- - 50%). The composition component of salt ions can describe the salinity of each well in the island.

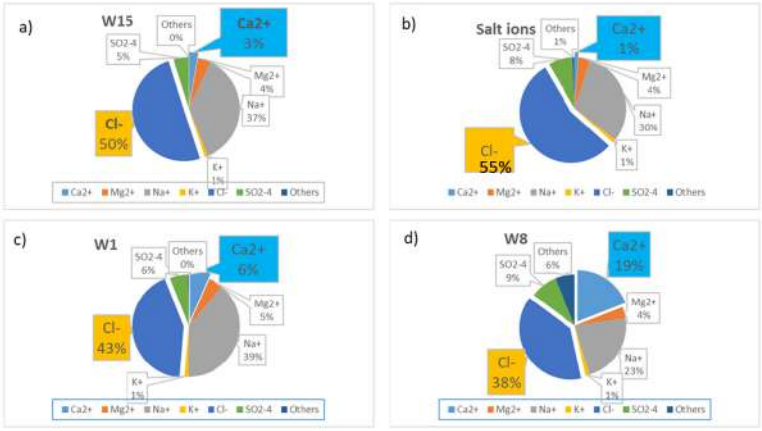


Figure 4. Diagram showing concentrations of various salt ions in the contamination of groundwater from seawater. The composition of the total salt component in a) W15, b) Seawater, c) W1 and d) W8

The impact of ongoing salinization found during pre-monsoon can be evaluated by the ionic strength variation in the groundwater. Figure 5 shows the water type classification based on ionic strength and Cl concentrations. The Cl was chosen because it is the most abundant ion in seawater. The scheme of ionic strength plotted against Cl on log-log scales produce of five major classes; fresh, slightly fresh, moderate, slightly saline and saline.

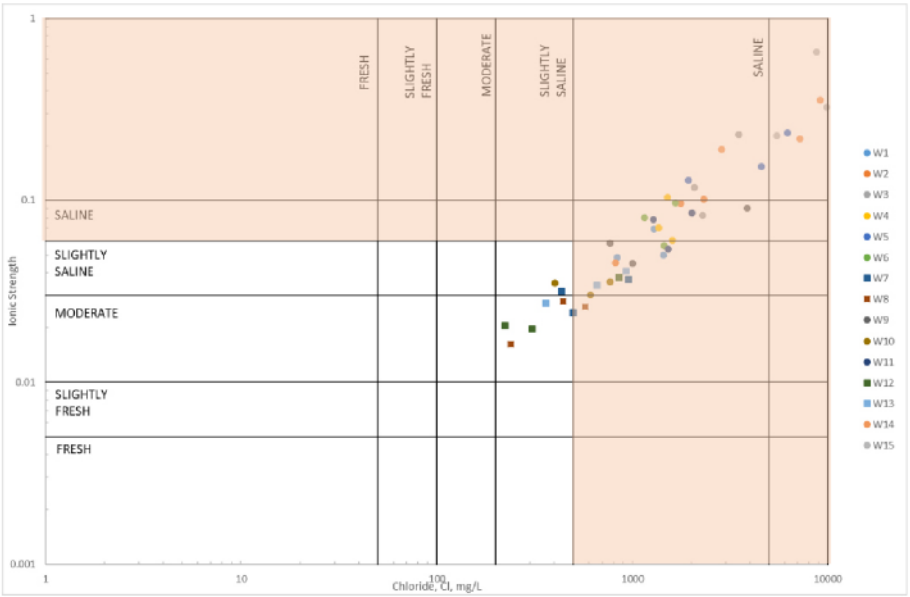


Figure 5. Assessment scheme for seawater intrusion based on ionic strength (I) against Cl concentration (after Mohd Isa &Aris, 2015)

Conclusion

Most of the wells are contaminated by saltwater. This may due to the excessive pumping activity from the resorts and the villagers. Chloride and sodium and EC have high value and were found to be exceeded the Malaysian and WHO drinking water standard. The values of water quality parameters such as pH and turbidity from all samples collected from public wells of the villages were found to be within the recommended limits of WHO. The concentrations of 7 heavy metals (Cu, Zn, Mg, Fe, Cd, Pb and As) were also measured and found to be well below the standard maximum concentrations. However, it is also important to investigate other potential water contaminations such as microbial and radiological materials for a longer period of time, including human body fluids, in order to assess the overall water quality of Mabul Island.

Acknowledgement

The authors would like to thank the Police Marine and JKKK Pulau Mabul for the support. The appreciation is also extended to all staff and technicians of the Hydrogeology Research Centre and Coastal management and Oceanography Research Centre, NAHRIM for their continuous help and support.

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ARSENIC REMOVAL BY ACTIVATED CARBON FROM DURIAN HUSK

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Abstract

The preparation of activated carbon from durian husk, variety D175 which also known as Udang Merah by chemical activation technique using zinc chloride (10%) as activating agent and its ability to remove arsenic in aqueous solutions were reported in this study. The proximate analysis of durian husk and the characterization of activated carbon using FTIR, SEM and SEM-EDX were evaluated. The influence of various factor such as weight of absorbent, arsenic concentration, contact time and pH were studied. Result from the study suggest that activated carbon prepared from durian husk, D175 has potential to be a promising precursor for the production of activated carbon with the excellent adsorption capacity to remove arsenic in aqueous solution.

Keywords: Durian Husk; activated carbon; arsenic; adsorption; kinetics

Introduction

Heavy metals pollution has become one of the most serious problem nowadays. The removal of heavy metals from the environment is of special concern due to their persistence – high solubility in aquatic environment, can be absorb by living organism. If the metals are ingested beyond permitted concentration, they can cause serious health disorder (reduced growth & development, cancer, organ damage, nervous system damage, death) (Ali et al., 2019; Zayat et al., 2006).

Contamination Sources – discharges by industries such as agrochemicals, petrochemicals and fertilizers and leaching of metals ion from the soil into lake and rivers by acid rain. Arsenic toxicities – skin manifestation, visceral cancers, vascular disease. Maximum Concentration Limit – 0.050 mg/L, Environmental Quality Act 1974, DOE – Standard A (0.05 mg/L) & Standard B (0.10 mg/L) (DOE, 1974), Environmental Protection Agency (EPA) – 0.01 mg/L (https://www.epa.gov/dwreginfo/drinking-water-arsenic-rule-history).

Basically, adsorption involves mass transfer process, which a substance is transferred from liquid phase to solid surface, and then bounded by physical and/or chemical interaction (Asadullah et al., 2014; Babel and Kurniawan, 2003). The fundamental concept in adsorption science also involves the explanation via adsorption isotherm fitting. A variety of equilibrium isotherm models have been formulated in terms of three fundamental approaches i.e. kinetic consideration, thermodynamics and potential theory (Foo and Hameed, 2010).

Generally, activated carbon (AC) is known as a versatile adsorbent. Its absorptive properties are due to their high surface area, microporous in structure and has a high degree of surface reactivity. In addition, different functional groups are present on AC surface with well-developed internal microporous structure and hydrophobic internal surface (Ansari, 2009; Ioannidou and Zabaniotou, 2007). Few researchers have reported the production of activated carbon from of durian biomass (Mohktar et al., 2013; Foo and Hameed, 2012; Chandra et al., 2007). In the present work, a by-product from agricultural industry, namely durian husk was

used as the precursor. Durian a from genus of Durio, belonging to the family Malvaceae which is native to Brunie, Indonesia and Malaysia. According to Ministry of Agricultural, Malaysia, the local production of durian fruit in 2011 was projected at 300,470 MT, translating to approximately 255,353 MT of durian shell as by product [http://ap.fftc.agnet.org/ap_db.php?id=904]. According to Marsh (2006), this industry already produces some hundreds of activated carbons, from traditional sources, with quite specific application attached to their spesifications. However, there is always the need for a new source of carbon, which will meet a demanding application.

Material and Methods

Proximate analysis of raw materials

The proximate analysis of D175 was conducted according to ASTM D 4442 for moisture content. ASTM E1755-01, Laboratory Analytical Procedure (LAP) NREL/TP-510-42622 for ash/inorganic content. ASTM E1690, Laboratory Analytical Procedure (LAP) NREL/TP-510-42619) for extractives content. TAPPI T203 cm-74 for holocellulose, hemicellulose and cellulose content.

Preparation of activated carbon (AC)

The durian husk, variety D175 was used as precursor for preparation of activated carbon. D175 was grinded with electrical blender. The dried D175 was impregnated with zinc chloride ($ZnCl_2$) at ratio of 1:10 for 24 hours with continuous stirring. The impregnated D175 was then heated until all $ZnCl_2$ solutions were evaporated on hot plate and further dried in the oven at 100 °C followed by cooled at room temperature and lastly sieved using 1 mm mesh. The treated D175was further carbonized in a tubular electrical furnace at temperature of 400 °C for 20 min and activation process at 800 °C for 30 min with heating rate 10 ºC/min. AC was washed with excess distilled water until the pH of filtrate reached approximately 6 – 7. The activated carbon was finally dried in the oven at 90 – 100 °C for 24 h before cooled at room temperature and stored in the desiccator until used.

The surface morphology of seed pod activated carbon was analyzed by Brunaeur-Emmett-Teller (BET) surface analysis, Scanning electron microcopy (SEM), FTIR spectrophotometry for functional group characterization and elemental content (CHN) was analyzed using Thermo Finnigan model Eager 300 analyzer.

Adsorption Study

The initial of concentration 5 mg/L As (pH=4, pH=7 & pH=10) were prepared in ultra-pure water. 0.05, 0.075, 0.1 & 0.15 g of AC was placed into the 50 ml arsenic solutions in a flask and shaken time to time at rt. After 60 minutes, the samples were withdrawn and filtered. Concentration of arsenic was determined using ICP-OES (Perkin Elmer, Optima 8300). All the standard and QC controls as follwed APHA 3120B method.

Kinetic Study

The initial of concentration of 5 mg/L (pH=10) were prepared. 0.05, 0.075, 0.1 & 0.15 g of AC was placed into the 50 ml arsenic solutions in a flask and shaken time to time at rt. 5 ml of each sample were withdrawn at different time interval for ICP-OES analysis within 15 to 60 minutes. Linear method is performed to analyses the divergence of Lagergren first order and Pseudo second order with experimental data of As removal.

The Lagergren pseudo-first order can be defined as Eq. 3 and pseudo-second order can be expressed by using Eq. 4

$$\log (q_e - q_t) = \log (q_e) - t\,(k_1/2.303) \quad (3)$$

$$t/q_t \;\; 1/k_2.q_e + t/q_e \quad (4)$$

Table 1 shown the result for proximate analysis of raw material, durian husk (D175). CHN analysis revealed that D175 contains mostly hydrocarbons (C, H and O) from carbohydrates with small amount of theoretical proteins. D175 was converted to activated carbon using zinc chloride as activating agent. These chemicals are common activating agents in activated carbon manufacturing industries which influence pyrolytic decomposition and inhibit tar formation.

Table 1. Result of proximate analysis of durian husk (D175) and CHN and BET analysis of AC

Moisture	11.41%	Carbon, C	22.29%
Ash	5.78%	Hydrogen, H	0.92%
Extractive content	11.81%	Nitrogen, N	1.10%
Hemicellulose	22.89%	Oxygen, O	74.69%
Cellulose	19.64%		
S_{BET} (m^2g^{-1})	826.12	V_{pore} (cm^3g^{-1})	0.054
S_{ext} (m^2g^{-1})	199.77	D_{pore} (nm)	1.743

Based on the pore diameter, 1.743 nm, the AC can be classified as microporous according to the International Union of Pure and Applied Chemistry (IUPAC, 1972) which classified as micropores (<2 nm diameter). On the most important features of adsorbents is their surface area and porosity. S_{BET} surface area for AC was found to be 826.12 m^2g^{-1} which were comparable with previous finding using ($ZnCl_2$, at temperature 700 to 750°C) – hazel nuts (793), rice husk (750), bagasse (674), olive stone (790) (Schröder et al., 2011; Tay et al., 2009; Kardivelu et al. 2003).

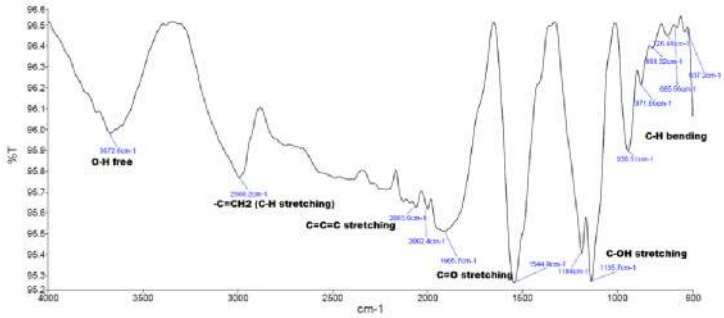
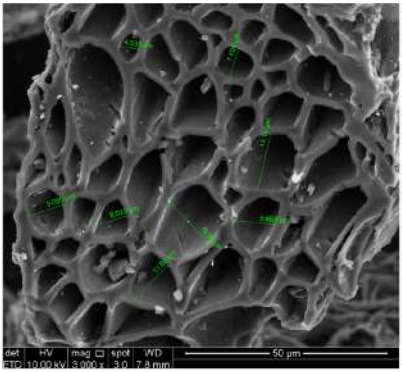


Figure 1. FTIR spectrum for activated carbon

The FTIR spectra show similar trends to that of previous findings by many authors and have five major's absorption bands at 3672 cm^{-1}, 2988 cm^{-1}, 2065 cm^{-1}, 1905 cm^{-1}, 1544 cm^{-1}, 1137 cm^{-1} and 637 – 938 cm^{-1} (Figure 1). The band at about 3672 cm^{-1} is attributed to O-H (stretching) and can be assigned to O-H vibrations, suggesting the presence of phenolic groups of cellulose and lignin. Treating biomass with oxidizing agents, $ZnCl_2$ introduce the surface of activated carbon with oxygen functional group.

The morphology of activated carbon was investigated using SEM. Scanning electron micrographs show changes in the morphology of the materials in terms of size and the formation of pores. It is worth noting, as seen in Figure 2, that the pyrolysis process has altered the morphology of activated carbon samples with formation of honeycomb-like pores, which are often aggregated, and a rough surface morphology of AC samples.



Processing option : All elements analyzed (Normalised)

Number of iterations = 10

Element	Weight%	Atomic%
C K	82.15	92.69
O K	4.03	3.41
S K	0.21	0.09
Cl K	5.62	2.15
Zn K	7.98	1.65
Totals	100.00	

Figure 2. IMAGE (3000X) and SEM-EDX

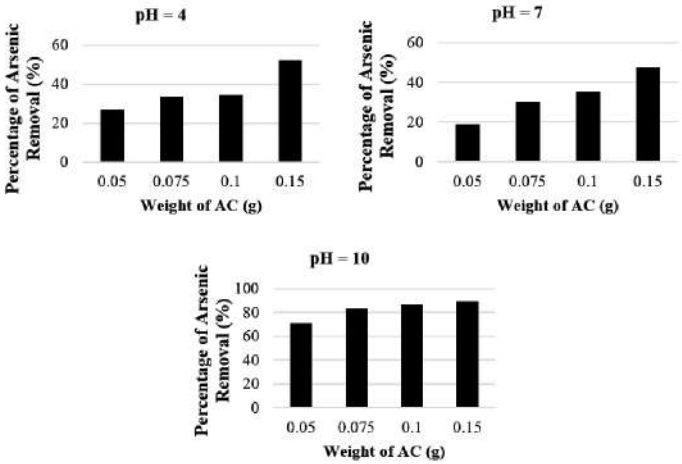


Figure 3. Bar Chart for Removal of Arsenic

Figure 3 shows the effect of pH values and weight of the AC on the efficiency of arsenic adsorption by AC. The result indicates that the adsorption of arsenic was most optimum at pH=10 with the removal (70% to ~ 90%). While, the percentage of arsenic adsorption were increased with increment of weight of AC used.

Conclusion

The present study revealed, the feasibility of using absorbent derived from D175, durian husk for the removal of arsenic from aqueous solution. Optimum removal condition was at pH=10, with AC at 0.15 g (~ 90%). Which, indicates that pH of aqueous solution is an important parameter in affecting adsorption of arsenic.

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MAGNETITE/TITANIA CORE-SHELL NANOPARTICLES: APPLICABILITY FOR ENDOCRINE DISRUPTOR CHEMICALS REMOVAL FROM CONTAMINATED WATER

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Abstract

The ever-increasing human demand for safe and clean water is gradually pushing conventional water treatment technologies to their limits. Nanoparticles offers the possibility of an efficient removal of contaminations in water and become one of the alternative product used for treating water and wastewater. In this study, we have investigated the sorption efficiency of Fe_3O_4/TiO_2 nanoparticles to remove endocrine disruptor chemicals (EDCs) compounds consists of organochlorine pesticides (OCPs) and Phenols. Fe_3O_4/TiO_2 coreshell nanoparticles were synthesized via sol-gel method with the aid of sonication. Due to the infinite size of Fe_3O_4/TiO_2 nanoparticles, the surface area is relatively large and, as result, Fe_3O_4/TiO_2 nanoparticles excellently perform in removing various EDCs in water. Fe_3O_4/TiO_2 nanoparticles has extended surface area at the value 754 m^2g^{-1} and high surface absorption area with the value 730 m^2g^{-1} proven by Brunauer–Emmett–Teller (BET) analysis. From morphology analysis using scanning electron microscopy(SEM) and transmission electron microscopy(TEM), it shows that titanium and iron exist in the sample with the particle size of 85 nm. The adsorption of EDCs compound behaviour was studied using the Triple Quadrupole Liquid Chromatography Mass Spectrometer (LC-MS/MS) and Triple Quadrupole Gas Chromatography Mass Spectrometer (GC-MS/MS). The results show, Fe3O4/TiO2 nanoparticles is able to remove OCPs and Phenols compounds from 62.4 % - 97 %.

Keywords: magnetite/titania; nanoparticle; endocrine disruptor chemical; sol-gel; adsorption

Introduction

The recent advancement in nanoparticles and nanotechnologies have shown promising potential in water purification for different contaminant removal. Such applications can be referred to many review papers (Mahmoudi et al., 2011; Teja & Koh, 2009; Savage & Diallo, 2005; Tratnyek & Johnson, 2006; Theron et al., 2008; Li et al., 2006). Nanoparticles possess high reactive capacity due to their large surface area. They can be functionalized with variouschemical groups to increase their affinity/selectivity towards a given compound. However, the separation difficulty of these particles always exists in practice due to their ultrafine size (Poursaberi et al., 2012). Magnetic nanoparticles (MNPs), which possess both the properties of nanoparticles and magnetic behaviours, make the nanoparticle recovery and recycle easier via magnetic separation, and thus find their wide applications in very different areas including water purification (Pope et al., 1994; Pieters et al., 1992; Raj et al., 1995; Lesile-Pelecky & Rieke, 1996; Berkovsky & Bashtovoy, 1996; Abo et al., 2001). The most widely used MNPs are iron oxide MNPs (mainly Fe3O4) or γ-Fe2O3). In recent years, a lot of work has been reported on the iron oxide based nanomaterials as purification media in water/wastewater treatment. This publication will discuss the sorption efficiency of Fe_3O_4/TiO_2 nanoparticles to remove endocrine disruptor chemicals (EDCs) compounds consists of organochlorine pesticides (OCPs) , Bisphenol S (BPS) and Bisphenol A (BPA).

Material and methods

Preparation of chromic acid for apparatus cleaning purpose

All apparatus was soak in chromic acid to remove any metal or impurities contact. Chromic acid was prepared by adding 20g of Potassium Chromate with sufficient distilled water to make a paste of the chromate salt. 300ml of concentrated sulphuric acid will be added. Use the mixture until it turn green in colour.

Preparation on Iron Oxide Fe_3O_4

Fe_3O_4 were prepared based a simple chemical co precipitation method [15]. Typically, 0.025 moL of $FeCl_2{\cdot}4H_2O$ and 0.05 moL of $FeCl_3{\cdot}6H_2O$ were freshly prepared in aqueous 10 mL HCl (2 M), respectively. Both $FeCl_2{\cdot}4H_2O$ and $FeCl_3{\cdot}6H_2O$ aqueous solution were then added rapidly to 20mL of ultrapure water and continuously stirred. Upon adding an aqueous NH4OH solution (28%, 4 mL), a distinctive black precipitate of Fe_3O_4 nanoparticles was formed immediately. Fe_3O_4 nanoparticles were isolated and purified by rotary evaporator and then washed with ultrapure water three to four times to remove excess NH_4OH solution.

Synthesis in situ of TiO_2 coated Fe_3O_4

30mg of Fe_3O_4 was add in 30 mL Ethanol and 6 mL H_2O. A mixture tetraethyl orthotitanate (TEOT), Ethanol (EtOH), deionized water (H_2O) and hydrochloric acid (HCl) was added to the Fe_3O_4 solution. The mole ratio TEOT: EtOH: H2O: HCl is 1:4:2:0.05. The mixture solution was sonicated for 2 hour. Fe_3O_4/TiO2 core-shell particles were isolated by magnetically separation and then washed with ultrapure water. Fe_3O_4/TiO2 core-shell particles was oven dried at 80°C for 24h followed by calcination at 500°C for 6h.

Charaterization and removal of OCPs, BPA & BPS

TiO_2 coated Fe_3O_4 particles will be characteriza via Brunaeur-Emmett-Teller (BET) surface analysis. Morphology studies will be conducted via Scanning Electron Microscopy with Energy Dispersive X-Ray Analyzer (SEM-EDX) and Transmission Electron Microscopy (TEM). The adsorption of BPA and BPS behavior will be studied under contact time using the Liquid Chromatography Mass Spectrometer (LCMS) and Triple Quadrupole Gas Chromatography Mass Spectrometer (GC-MS/MS)

Results and Discussions

Brunaeur-Emmett-Teller (BET) surface analysis

The BET surface area, external surface area, total pore volume and the pore size of the samples were determining by using Brunauer-Emmett-Teller (BET) equation and Quantachrome Nova Win2(c) 1994-2002.

From this, BET derived the BET equation:

$$v = \frac{v_m c p}{(p_0 - p)\{1 + (c-1)(p/p_0)\}}$$

A more convenient form is the following:

$$\frac{p}{v(p_0 - p)} = \frac{1}{v_m c} + \frac{c-1}{v_m c}\frac{p}{p_0}$$

p = partial vapour pressure of adsorbate gas in equilibrium with the surface at 77.4 K (b.p. of liquid nitrogen), in pascals,

po = saturated pressure of adsorbate gas, in pascals,

v = volume of gas adsorbed at standard temperature and pressure (STP) [273.15 K and atmospheric pressure (1.013 × 105 Pa)], in millilitres,

vm = volume of gas adsorbed at STP to produce an apparent monolayer on the sample surface, in millilitres,

c = dimensionless constant that is related to the enthalpy of adsorption of the adsorbate gas on the powder sample.

Table 1. BET results

BET analysis	Value
S_{BET} (m^2 g^{-1})	**730**
S_{ext} (m^2 g^{-1})	**754**
V_{pore} (cm^3 g^{-1})	**0.47**
D_{pore} (nm)	**2.58**

* SBET, BET surface area; SEXT, t-plot external surface area; VPORE, BJH adsorption pore volume and DPORE, average pore diameter.

From table 1, titania prepared gives the average pore diameter 2.58 nm with the surface area of 730 m2 g-1 . According to the International Union of Pure and Applied Chemistry (IUPAC, 1972) , this TiO2 coated Fe3O4 can be classified as micropores. High value of surface area leads titania to good absorption properties.

Scanning Electron Microscopy with Energy Dispersive X-Ray Analyzer (SEM-EDX)

Scanning electron microscopy (SEM) analysis for powdered samples were carried out at HV value of 10 kV and magnification of 12k x. The elemental composition was obtained by carried out the analysis using Quanta FEI 650 instrument. The samples were analyzed at 200 x magnification.

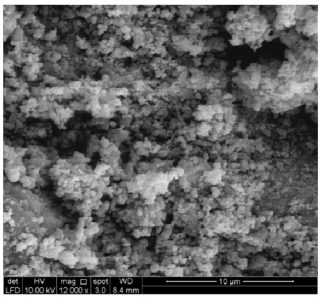


Table 2: Element composition

Element	Weight%
C	5.06
Ti	47.79
O	39.37
Fe	7.78
Totals	100.00

Figure 1. SEM micrograph of TiO2 coated Fe3O4

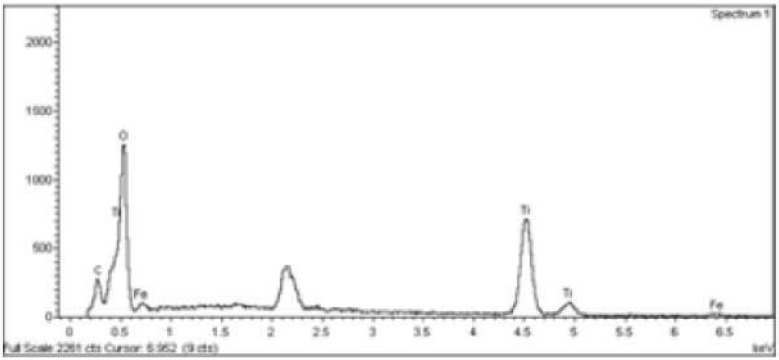


Figure 2. EDX spectrum

From the TiO_2 coated Fe_3O_4 micrography in Figure 1, it shows that titania particles were form with rough surfaces. The EDX spectrum as shown in Figure 2 revealed the presence of three elements (C, O, Ti, Fe). The composition of each element is clearly stated in Table 2.

Transmission Electron Microscopy (TEM)

The transmission electron microscopy (TEM) images were taken using a Philips M12 at an operation voltage of 120 kV. For the measurement of the silica samples, the small pieces of the material were placed onto the TEM-grid.

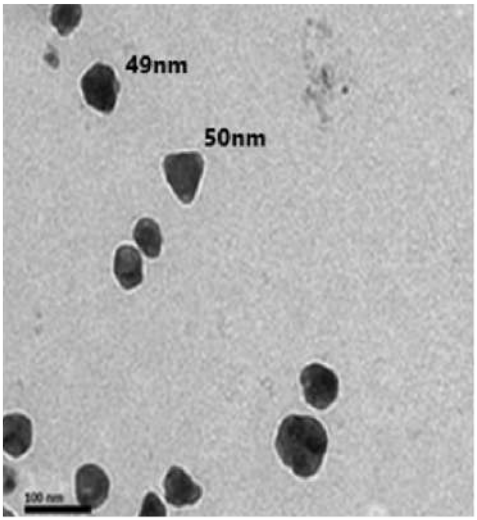


Figure 3. TEM micrograph of titania

The formation is particle almost spherical was found in Figure 3. The TEM micrograph reveals the porous TiO2 coated Fe3O4 particles having particle sizes of 40-60 nm. The diameter of titania particles from the sol-gel method is controlled by the relative contribution from nucleation and growth processes.

Liquid Chromatography Mass Spectrometer (LCMS)

Identification of peak concentrations was made by means of a chromatogram of a standard solution of each compound. BPS & BPA was identified by respective retention time and peak area. Optimum condition to identified and quantified Bisphenol S & Bisphenol A are as per below:-

Instrument High-Performance Agilent 6470A Triple Quadrupole LC/MS	
Analytical Column	:Zorbax Eclipse Plus C18 2.1x50mm,1.8um
Guard Column	:Infinity In-line filter with 0.3um SS frit
Injection volume	:10 uL
Mobile phase	:A= UPW +5mM ammonium acetate; B=(90% ACN + 10% UPW)+ 5mM ammonium acetate
Run time	: 6.4 min + 1.5 min post time
Flow rate	: 0.4 ml/min

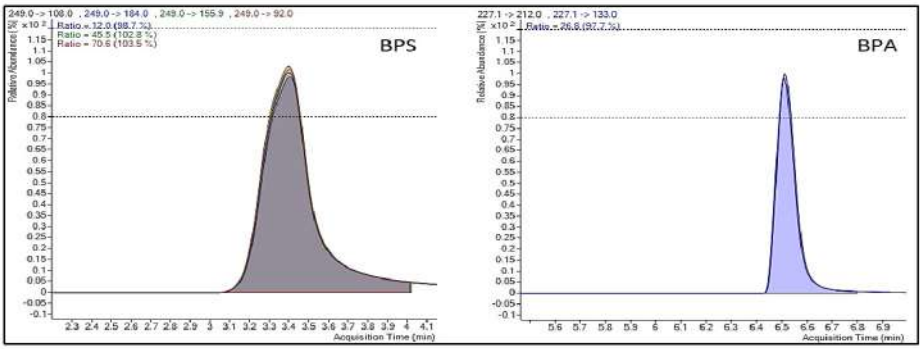


Figure 4. Relative abundance of BPA & BPS

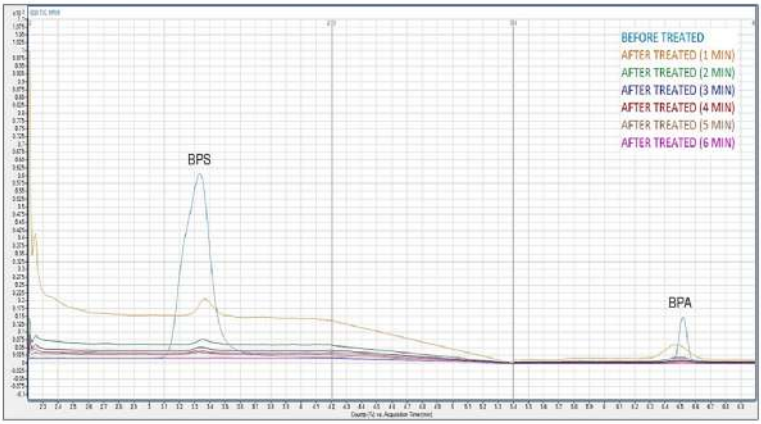


Figure 5. BPA & BPS Chromatogram treated with TiO2 coated Fe3O4

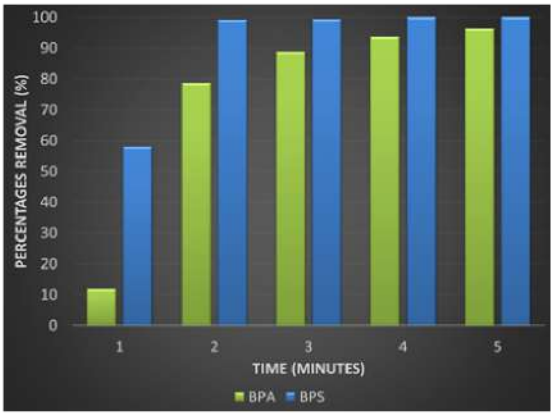


Figure 6. Percentages of BPA & BPS removal

As per figure 4, the retention time for the compound Bishenol A(BPA) and Bisphenol-S (BPS) around 6.5 minute and 3.5 minute using LC-MS/MS. As the mixture of BPA and BPS aqueous solution was introducing to TiO_2 coated Fe_3O_4, the concentration of BPA and BPS decrease. This is shown in Figure 5. Figure 6 shows TiO_2 coated Fe_3O_4 successfully remove up to 97% of BPA and BPS in 5 minutes.

Triple Quadrupole Gas Chromatography Mass Spectrometer (GC-MS/MS)

Identification of peak concentrations was made by means of a chromatogram of a standard solution of each compound. OCPs was identified by respective retention time and peak area. Optimum condition to identified and quantified OCPs are as per below:-

Instrument High-Performance Agilent 7890B Triple Quadrupole GC/MSMS			
Column	: HP 5 MS	Purge Time	:0.75 min
Injection volume	: 1 uL	Injector Temperature	: 220 oC
Carrier Gas	: Helium	Detector Temperature	: 300 oC
Head Pressure	: 21 psi	Sampling rate	: 20 Hz
Split Flow	: 75 mL/min		

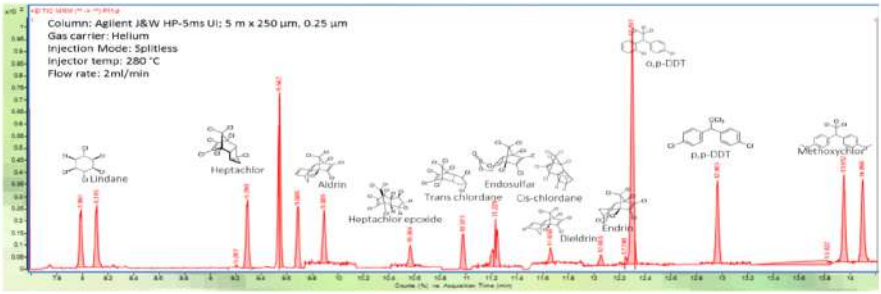


Figure 7. OCPs Chromatogram

Compound	1min	2min	3min	4min	5min
Aldrin	35.5	47.4	73.5	81.7	85
Dieldrin	74	87.5	93.9	95	100
Chlordane-cis	75.5	88.6	94.8	96	100
Chlordanetrans	73.6	87.6	94.9	96	100
DDT-o,p	78	90.9	100	100	100
DDT-p,p	91	93.8	99.2	99	99.5
Heptachlor	58.9	60.1	90.6	94.6	100
Heptachlor epoxide	52.9	66.7	84.5	92.4	97
Methoxychlor	100	99.9	100	100	100
Lindance	73.3	79.3	99.9	100	100
Endosulfan	77.3	100	100	100	100
Endrin	82	94.5	100	100	100

There are 12 compounds in OCPs consist of Aldrin, dieldrin, chlordane-cis, chlordance trans, DDT-o,p , DDT-p,p, heptachlor, heptachlor epoxide, methoyxchlor, lindance, endosulfan and endrin As OCPs was introducing to magnetite/titania, the concentration of OCPs decrease. This shows Magnetite/titania successfully remove more than 85 % of OCPs in 5 minutes as per Table 3.

Conclusions

Magnetite/Titania Core-shell nanoparticles were successfully synthesized via sol gel process. Magnetite/ Titania Core shell nanoparticles has high surface absorption area. From morphology analysis it shows that titanium and iron exist in the sample with the particle size of 40-80 nm. Due to the infinite size of Magnetite/ Titania Core shell nanoparticles , the surface area is relatively large and, as result, Magnetite/ Titania Core shell nanoparticles excellently perform in removing BPA, BPS and OCPs contaminant in water.

Acknowledgments

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WATER QUALITY EVALUATION OF SUNGAI ICHAT, CAMERON HIGHLAND

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Abstract

The encroachment of farming activities into the Kuala Terla water catchment area, especially near to the intake point of the Sungai Ichat Dam in Ulu Ternom sub-district, has resulted in the deterioration of Sungai Ichat. Contamination of Sungai Ichat water quality not only affecting the environment but also poses a great risk to public health because it is one of the two major raw water sources for Kuala Terla Water Treatment Plant, with the catchment area of 10.478 km2. This study was carried out to evaluate the water quality condition of Sungai Ichat via analy-sis of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Suspend-ed Solids (SS), turbidity, ammonia, pH, temperature, heavy metals and pathogen-ic indicator. Findings from this study shows high level of E.Coli and Total Coli-form due to intensive farming activities, involving continuous applications of fer-tilizers in the buffer area of Sungai Ichat . Based on the findings, Sungai Ichat was classified in Class II based on the National River Water Quality Standard classification. In conclusion, the water quality of Sungai Ichat is highly affected by the surrounding farming activities. Thus, in order to ensure Sungai Ichat is clean and healthy, the sources of pollutant discharge from landuse activities along Sungai Ichat must be identified and controlled.

Keywords: water quality, pathogenic indicator, fertilizers , buffer zone, land use.

Introduction

Surface waters can be contaminated by human activities in two ways: (1) by point sources, such as sewage treatment discharge and storm-water runoff; and (2) by non-point sources such as runoff from urban and agricultural areas. Non-point sources are especially difficult to detect since they generally encompass large areas in drainage basins and involve complex biotic and abiotic interactions (Camara et al., 2018). Natural catchment characteristics such as topography and surficial geology also plays a significant role in surface water quality condition. For example, the biochemi-cal processes in the terrestrial environment dominate the hydrochemical response of small catchments, because stream water is largely made up of drainage from soils (Sanden et al., 1997). Despite their importance, the influences of natural landscape variables are not usually included in catchment management studies because they considerably complicate the analysis.

Furthermore, types of land use activities

within the catchment has great impacts on the water quality of rivers. The water quality of rivers may degrade due to the changes in the land cover patterns within the catchment as human activities increase. Agriculture, which accounts for 70 percent of water withdrawals worldwide, plays a major role in water pollution. Farms discharge large quantities of agrochemicals, or-ganic matter, drug residues, sediments and saline drainage into water bodies (Chim-wanza et al., 2005, Ward et al., 2018). 38 percent of water bodies in the European Union are under pressure from agricultural pollution. In the US, agriculture is the main source of pollution in rivers and streams, the second main source in wetlands and the third main source in lakes (FAO, 2016; USEPA 2016). In China, agriculture is respon-sible for a large share of surface-water pollution and is responsible almost exclusively for groundwater pollution by nitrogen (USEPA, 2016; Wu and Sun, 2016)

Improperly managed farming activities along the riverbank has a significant im-pact on surface water by contributing nutrients, pesticides, sediment, and bacteria, or by altering stream flow (Sasakova et al., 2018 and USEPA, 2016). Fertilizer and pes-ticide used in farming can be one of the key source of water quality degradation. Farming activities increase the potential for nutrient and pesticide transport to nearby surface waters and ground water below agricultural fields. Base flow in nearby streams, lakes, or wells may be affected by intensive irrigation that draws down the ground water table. This pollution poses demonstrated risks to aquatic ecosystems, human health and productive activities. For example, high levels of nitrates in water can cause "blue baby syndrome", a potentially fatal illness in infants (Ward et al., 2018).

Sungai Ichat is affected by land development activities for farming purposes. It is therefore affecting the balance of nature, particularly towards the source of water at Sungai Ichat. At the moment, Sungai Terla is the river that supplies 70 percent water supply of Cameron Highlands, however Pahang State Government plans to retrieve Sungai Ichat as supporting role for water supply in near future. This study aims to determine the water quality status based on physical, chemical and pathogenic pa-rameters in Sungai Ichat, Cameron Highland including the heavy metal parameters.

Methods

Physical and chemical parameters analysed to determine the quality of Sungai Ichat are: Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Ammoniacal Nitrogen (NH3-N), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Total Solids (TS), Nitrite (NO_3), Nitrite ($N0_2$), Total Nitrogen (TN), Total Phosphorus (TP), Phosphare ($P0_4$), Total Organic Carbon (TOC), Total inorganic carbon, Total Carbon (TC), Chlorophyll-a, Oil and Grease, and heavy metals (Al, As, Ba, Cd, Cr, Cu, Ca, Mg, Na, Fe, Pb, Mn, Ni, Se, Ag, Sn, Zn, B, Hg). All sampling bottles were washed with distilled water prior analysis to ensure no impuri-ties found in the bottle that can affect the water samples. Water samples were col-lected at ten locations starting from the upstream of Sungai Ichat and end at the confluent of Sungai Ichat and Sungai Terla (Figure 2.1).

Pathogenic indicators of Total coliform, E. *Coli*, Total Fecal Coliform were also analysed and samples were collected using sterile bottles. In-situ measurement of temperature, dissolved oxygen (DO), conductivity, turbidity, salinity and pH were obtained using YSI Model 6600. Multi probe system (MPS). This instrument was calibrated and cleaned before being used for the sampling.

All water samples were stored in temporary ice box container covered with ice cu-be to keep the temperature at 4°C and immediately being transported to the laborato-ry within the holding time of 24-hours for analysis.

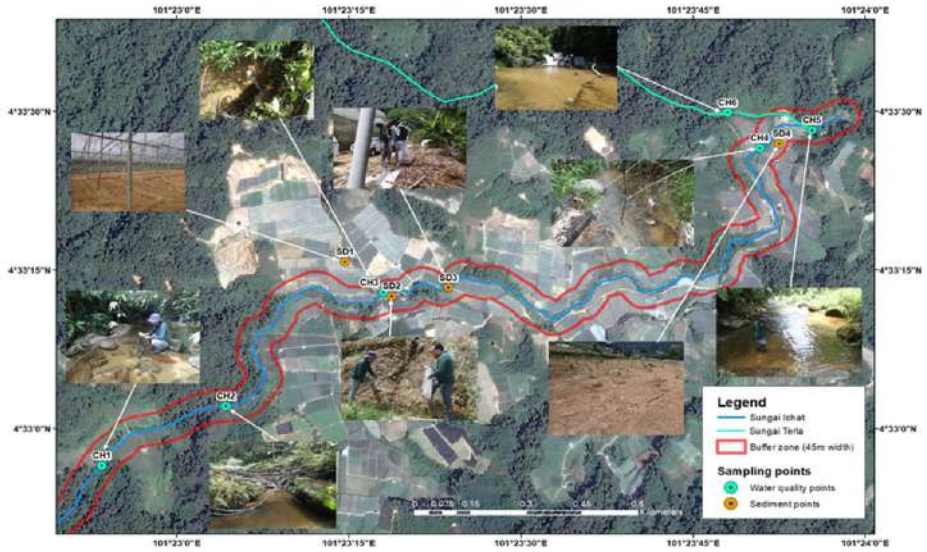


Figure 2.1. Sampling Locations at Sungai Ichat, Cameron Highland

Results

The analysis of water quality parameters indicated that the water quality of Sungai Ichat is in Class II of National River Water Quality Standard (DOE) as dis-played in Table 3.1.

Table 3.1. The Water Quality Status following Malaysia De-partment of Environment River Water Quality Standard

POINT	DO%	BOD	COD	SS	P_H	NH_3-NL	WQI	CLASS	WQ STATUS
CH 01	107.06	1.1	5.4	9	6.07	0.09	94.34	I	Clean
CH 02	108.80	2.2	21.6	9	5.97	0.09	90.17	II	Clean
CH 03	110.48	1.6	20.4	9	6.09	0.09	91.10	II	Clean
CH 04	108.78	1.2	6.9	14	6.05	0.09	93.46	I	Clean
CH 05	116.66	0.09	4.1	12	6.61	0.09	95.87	I	Clean
CH 06	116.84	0.09	4.2	9	6.22	0.09	95.65	I	Clean

Heavy metals analysis also indicated a below range of detection level or within the acceptable limit of National Drinking Water Standard of Malaysia Ministry of Health. However, the pathogenic parameters showed higher values than acceptable value based from raw water quality standard and National Drinking Water Standard of Malaysia Ministry of Health. Details analysis is as illustrat-ed in Table 2.

Table 3.2.

No.	Test Parameter	CH 01	CH 02	CH 03	CH 04	CH 05	CH 06	Unit
1	Chemical Oxygen Demand	5.4	21.6	20.4	6.9	4.1	4.2	mg/L
2	Nitrogen Ammonia (NH3-N)	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	ND<0.1	mg/L
3	Biochemical Oxygen Demand	1.1	2.2	1.6	1.2	ND<1.0	ND<1.0	mg/L
4	*Total Coliform	$2.08X10^3$	$9.65X10^3$	$2.81X10^4$	$9.75X10^4$	$2.25X10^4$	$1.18X10^4$	cfu/100ml
5	*Escherichia coli	720	$3.75X10^3$	$4.95X10^3$	$3.6X10^4$	$5.20X10^3$	$2.70X10^3$	cfu/100ml
6	*Total Faecal Coliforms	575	550	$5.05X10^3$	$1.16X10^4$	$4.30X10^3$	800	cfu/100ml
7	Total Suspended Solids (TTS)	ND<10	ND<10	ND<10	14	12	ND<10	mg/L
8	Total Solid (TS)	51	55	58	77	45	44	mg/L
9	Total Suspended Solids (TDS)	46	44	49	63	27	35	mg/L
10	Total Inorganic Carbon	0.39	0.85	2.26	1.83	0.26	0.38	mg/L
11	Total Carbon	3.29	15.64	5.04	11.8	5.79	5.55	mg/L
12	Total Organic Carbon	2.9	14.79	2.78	9.97	5.53	5.17	mg/L
13	*Total Nitrogen	0.21	0.31	1.44	3.25	1.53	0.32	mg/L
14	Phosphate (PO_4)	ND<0.16	ND<0.16	ND<0.16	0.49	ND<0.16	ND<0.16	mg/L
15	*Nitrate (NO_3)	0.68	0.91	6.94	14.25	5.85	1.14	mg/L
16	*Nitrate (NO_2)	ND<0.05	ND<0.05	ND<0.05	ND<0.05	ND<0.05	ND<0.05	mg/L
17	*Total Phosphorus (PO_4)	ND	0.03	0.07	0.19	0.1	0.04	mg/L
18	*Chlorophyll-a	ND<1	0.92	ND<1	ND<1	0.91	ND<1	µg/L
19	*Oil & Grease	0	6.3	0	0	1.4	0	mg/L
20	Lead, Pb	0.01	0.01	0.01	ND<0.01	ND<0.01	ND<0.01	
21	Zinc, Zn	0.11	0.05	0.05	0.05	0.05	0.04	
22	Aluminum, Al	0.11	0.16	0.16	0.33	0.22	0.11	
23	Nickel, Ni	ND<0.005	ND<0.005	ND<0.005	ND<0.005	ND<0.005	ND<0.005	
24	Chromium, Cr	0.04	0.05	0.05	0.05	0.05	0.05	
25	Iron, Fe	ND<0.20	0.3	0.23	0.33	0.41	0.39	
26	Boron, B	ND<0.01	ND<0.01	ND<0.01	ND<0.01	ND<0.01	ND<0.01	mg/L
27	Cuprum, Cu	0.068	0.065	0.064	0.054	0.051	0.049	
28	*Selenium, Se	0.01	ND<0.01	ND<0.01	ND<0.01	ND<0.01	ND<0.01	
29	*Argentum, Ag	0.006	ND<0.005	0.005	ND<0.005	ND<0.005	ND<0.005	
30	*Tin, Sn (in house)	ND<0.01	ND<0.01	ND<0.01	ND<0.01	ND<0.01	ND<0.01	
31	*Barium, Ba	0.009	0.02	0.034	0.042	0.024	0.014	
32	*Manganese, Mn	0.006	0.023	0.027	0.038	0.026	0.027	
33	*Cadmium, Cd	ND<0.005	ND<0.005	ND<0.005	ND<0.005	ND<0.005	ND<0.005	
34	*Arsenic, As	ND<0.02	ND<0.02	ND<0.02	ND<0.02	ND<0.02	ND<0.02	
35	*Magnesium, Mg	0.24	0.43	0.95	1.69	1.15	0.61	
36	* Natrium, Na	1.71	1.97	2.57	3.38	2.66	2.08	
37	*Calcium, Ca	0.73	1.13	2.96	5.15	3.7	1.22	
38	Mercury, Hg	ND<0.20	ND<0.20	0.56	ND<0.20	0.52	ND<0.20	µag/L

Discussion

Elevated levels of E. coli, which are indicative of fecal contamination may indi-cates the potential presence of other enteric pathogens in the impaired water bodies (Harmel et al., 2010). Contamination of streams with E. coli often results from a combination of human and animal fecal material from point and nonpoint sources (Scanlon et al., 2007). At the field-scale sites, different fertilization schemes may have to be examined to assess the impact of common nutrient sources used in the region (inorganic fertilizer and dairy manure compost).

The preliminary results show that there are clear differences between catchments with varying land uses that are worth further investigation. However, as was the case in this study, the use of existing databases that were not developed with clear aims can, at best, be used for tentative exploratory and hypothesis-generating purposes. Further investigations will require a better designed spatial and temporal sampling regime as well as higher resolution digital maps with more land use classes.

The best way of mitigating pressures on aquatic ecosystems is to avoid or limit the export of pollutants. Simple off-farm techniques, such as riparian buffer strips or constructed wetlands, can cost-effectively reduce loads entering surface water bodies. Buffer strips are a well-established technology. Vegetated filter strips at the margins of farms and along rivers are effective in decreasing concentrations of pollutants entering waterways.

Integrated systems in which crops, vegetables, livestock, trees and fish are man-aged collectively can increase production stability, resource use efficiency and envi-ronmental sustainability. Integrated farming ensures that waste from one enterprise becomes inputs to another, thereby helping to optimize the use of resources and reduce pollution.

Before any action, to design cost-effective measures for preventing pollution and mitigating risks, managers, planners and lawmakers need to know the state of aquatic ecosystems, the nature and dynamics of the drivers and pressures that lead to water-quality degradation, and the impacts of such degradation on human health and the

Conclusions

The results suggest that the farms along the riverbanks have an impact on the wa-ter quality of the water in the river. It is therefore recommended that there should be close monitoring of the activities of the farms on riverbanks to minimise their impacts on the natural ecosystems that they interact with. Frequent monitoring of the water quality in the rivers relative to the farming estates should be done. Diagnosis, predic-tion and monitoring are key requirements for the management of agricultural prac-tices that mitigate these harmful impacts on water resources.

Therefore, the paper recommends some of the ways of practicing farming that should be followed in order to curb the deterioration of the quality of water in lakes and rivers and these recommendations includes the prevention of practicing farming along the river banks, the reduction in the amount of synthetic fertilizers and organic manure to the fields, and by not applying the pesticides that are not recommended and poses an adverse effect of toxicating water bodies. This result indicates the need for improved understanding of anthropogenic and background E. coli sources and of bacterial fate, transport, and survival in upland terrestrial environments, so upland and down- stream sources can be effectively and efficiently managed.

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SEASONAL VARIABILITY OF SALINITY, TEMPERATURE, pH AND DISSOLVED OXYGEN IN THE TERENGGANU ESTUARY DURING DRY SEASON

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Abstract

Nutrient levels in an estuary depend strongly on tidal fluctuations, river & effluent discharge that drain into estuary and local geomorphology conditions. In this study, we investigated the baseline water quality conditions through ebb and flood tide during dry season in Terengganu estuary. Hourly water quality profiles for four constituents namely salinity, temperature, pH and dissolved oxygen were observed for 30 hours using YSI at two selected fixed stations. Data campaign also measured profile water quality for 20 defined stations during low and high water along longitudinal axial using calibrated YSI probe. It found that 80% of the time, water from the estuary was flowed into South China Sea through ebb tide, causing the entire estuary filled up by fresh water and only a distance of 3 km from river mouth affected by saline water. While during high water, saline water reached at 9.5 km inland with magnitude of 6.5 ppt. During ebb tide, fairy uniform distributed cooler water temperature ranging from 28.4°C to 29°C was observed in the estuary, meanwhile at flood tide, hotter and strong stratified water temperature vary from 28.7°C to 30°C was recorded, with hotter water situated at the bottom layers. Lower pH, with strong stratified vary from 6 to 7.0 was observed at the bottom layers during ebb tide, while due to flushing effects during flood tide causing the mixture of fresh water with tidal brackish water, which was contributed to fairy uniform pH ranging from 6 to 8 in the estuary water column. During low water, unhealthy DO level was reported at the bottom layers of estuary, vary from 3 mg/l to 3.7 mg/l, while during high water with saline water input, the higher DO magnitude ranging from 3 mg/l to5.3 mg/l was recorded, however DO level at the lower estuary found to be worsened than upper estuary. It can be revealed that tidal flushing, effluents discharge and water residence times play an important role in nutrient levels in the estuary.

Keywords: Terengganu Estuary, Salinity, Temperature, pH, DO, Dry season.

Introduction

The transport of nutrient, salt, dissolved oxygen, pH, temperature and others constituents in the estuary depends greatly on hydrodynamic circulations generated by tidal fluctuations, river discharge, discharge of effluent contamination into estuary, atmospheric forcing and local geomorphology (Becker et al. 2010; Krumme, 2012). Estuary is the most productive ecosystem and recognized as important ecosystem in generating high fish productions (Abowei, 2010; Ghosh et al. 2012) Nevertheless it was noted that decade ago, nature and anthropogenic activities have leaded the estuary to periodic or permanent elimination of its functions (kasai et al. 2009; Abowei, 2010). Therefore in order to maintain and sustain a healthy estuary, it is important to understand the existing water quality conditions in an estuary for future estuary management plan.

Knowing the water properties in estuary can be extremely dynamic both in space and time, associated with rise and fall of sea level

fluctuations that influence changes in physical, biological and chemical parameters, which manipulate plankton production in estuary (Krumme et al. 2012). Investigation of tidal induced dynamic is also paramount to establish in this study. Study area is located at the centre of urban city, surrounded by rapid developments. Industrial effluent, municipal discharge, agricultural runoff and sand mining waste discharge from upstream may result in the contamination of food chain when entering the river system (Sultan et al. 2010). Our data collection was in July 2012, revealed the partial information on tropical estuary water quality characteristics for salinity, dissolved oxygen, pH and water temperature variables during dry season. This study has developed strong understand in basic water quality fluxes and processes in the Terengganu estuary. We hypothesized on Terengganu estuary water quality during dry season as: (1) effluents discharge from surrounding estuary lead to low pH and DO in the mid and lower estuary (2) longer water residence time during low water, coupled with lower current flow, higher water temperature and less saline water worsens the DO in estuary water column.

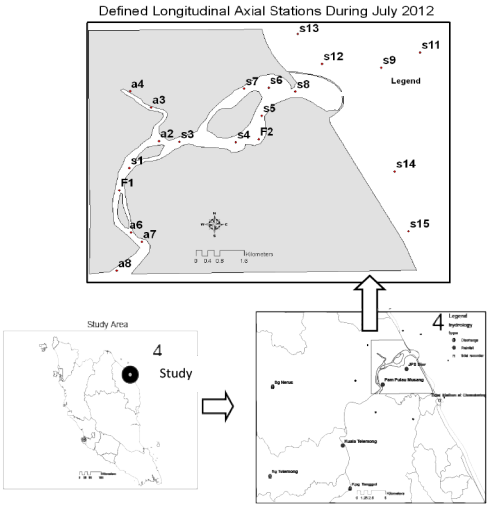


Figure 1. Study area and define longitudinal axial stations. Location of YB and Manir station was marked as F2 and F1 respectively.

Materials and methods

Terengganu River is 65 km long, located at east cost of Peninsular Malaysia, comprising a catchment area of 4,650 km2 (Fig 1). The average monthly discharge was approximately 266 m3/s, the main stem begins from Kenyir Dam and flows eastwards, draining into South China Sea. River mouth is protected by breakwater with 200 m length of breakwater opening width for navigation channel. This region is undergoing rapid developments in the industry sector and urbanization (Sultan et al. 2010).

Data campaign was undertaken by three groups of researchers for duration of 30 hours, started at 15 July at 10 o'clock morning to 16 July 2012 at 4 o'clock in noon. Weather during data campaign was clean, hot and no wind. Measurements were made during early state of spring tide and observations consist of two units of sea bed fixed ADCP and two units fixed automatic tide gauges. Those equipments placed at fixed stations namely Yellow Buoy (YB) and Manir station which is located at 1.5

km and 9.5 km away from river mouth (Fig 1c). All the equipment was well calibrated and verified before used. Hourly vertical water quality profiles on salinity, temperature, dissolved oxygen (DO) and pH was measured using YSI with appropriate weight at the bottom, measurements were made at 0.5 m from the surface water and subsequence 1 m till it reached sea bed. Those YSI equipments were well calibrated and verified before been used at the site. Water quality observations were made at fixed stations and moving longitudinal axial with fiber boats. Two groups of researchers had permanently anchored their fiber boat at a fixed station namely Yellow Buoy (YB) and Manir station. Meanwhile another group of researchers travelled along longitudinal axial and measured water quality at 20 defined stations as shown in Figure 1c: During the 1st day (15 July at 10 pm), measurement was took at low water, started from offshore towards inland and upon reached at last station landward, it was almost slack low water. Meanwhile at 16 July at 8am, measurement started at slack high water and traveled from inland toward offshore.

Results and discussion

Marine hydraulic conditions

Marine hydraulic conditions as displayed in Figure 2, indicates the hydraulic behaviors in the estuary for ebb and flood tide. In a day, 80% of the water in the estuary will flow towards sea as ebb tide with average current speed of 0.3 m/s and 0.1 m/s at YB and Manir station respectively (Fig 2a, 2b and 2c). It means during low water, current speed at YB is flowing faster than Manir station; perhaps it might be subjected to ADCP deployment location, adjacent to navigation channel.

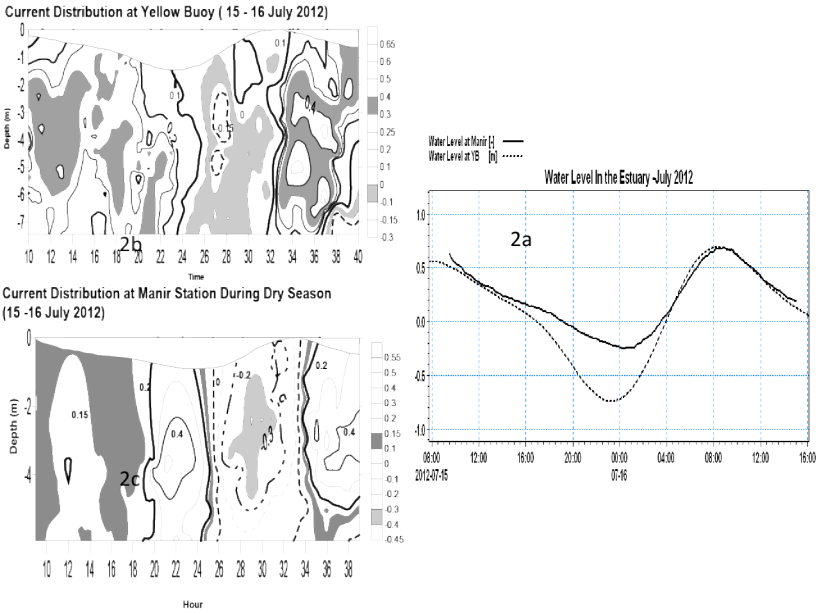


Figure 2. Marine water conditions. 2a: comparison on water level in estuary between YB (dotted line) and Manir station (solid line), which located at lower and upper stretches of estuary respectively. 2b: YB station current speed and 2c: Manir station current speed

Meanwhile during flood tide, current speed at YB illustrates five hours in day water from the sea will intrude into the estuary through bottom layer as salt wedge with average magnitude of 0.1 m/s (Fig 2b). At the upper stretch of estuary, velocity at Manir station shows higher current speed take place at mid depth of water column with the magnitude of 0.4 m/s flow landward (Fig 2c).

Water quality conditions at fixed stations

Salinity at the Yellow Buoy (YB), located at the lower estuary, approximately 1.5 km from the river mouth, was experienced salt water intrusion from the sea. The higher salt density was 33 ppt, stronger stratified took place during high water slack. During the data campaign, entire 2 m height of sea bed covered by minimum density of 5ppt saline water with the lowest at slack low water (Fig 3a). Manir station, which located 9.5 km from the river mouth, was experienced salt intrusion for duration of 5 hours during high water slack with the magnitude of 6.5 ppt at the mid depth (Fig 3b). At YB station, hotter water with magnitude varies from 29.2°C to 31°C can be found at the bottom layer and a strong stratified temperature took places during high water (Fig 3c). Meanwhile at Manir station, the water temperature was distributed uniformly from surface to bottom layers, the average cooler water temperature took place during flood tide and the hotter water temperature occurred during ebb tide, with magnitude of 28.2°C and 28.8°C respectively(Fig 3d).

Lower estuary as the transitional area where fresh water meets with saltwater is having higher variation range of pH (Fig 3e) compared to the upper estuary which is sorely affected by fresh flows (Fig 3f). At the YB, pH values ranging from 6.4 to 9, while at Manir station the pH ranging from 6.4 to 8. Both stations show lower degree of pH took place at bottom layer of the stations. YB station is experiencing depletion of oxygen in the water column with DO varies from 0.8 to 3.5 mg/l, higher DO is found at water surface (Fig 3g). Meanwhile Manir station which is 9.5 km from the river mouth, demonstrates a more uniform distribution of DO from surface to bottom, with DO level varies from 3 to 4 mg/l.

Water quality in longitudinal conditions

During ebb tide, fresh water occupied almost the entire lower estuary. The estuary was strongly stratified, length of seawater intrudes to estuary is approximately 3 km from the breakwater opening (Fig 4a, 5a). Due to absent seawater in the mid and upper stretches of estuary (Fig 4b, 5b), the temperature in these zones is uniform, average fresh water temperature is 28.8oC, while near-shore temperature recorded as high as 30oC. pH and DO (Fig 4e, 4f, 5e and 5f) seems to be influenced by localized effluent effects, acidic water with low DO (magnitude of 6.0 and 3.3 mg/l) was recorded and mostly situated at bottom layers, this happen perhaps due to decompose of organic waste effluents from landuse activities adjacent to estuary.

Flood tide, allows seawater to intrude further inland through bottom layer as salt-wedge. A sharp halocline (Fig 4c, 5c), indicated the estuary is strongly stratified. Salt intrusion with density of 2 ppt reaches a distance of 10 km from river mouth. Stratified water temperature can be seemed at the upper estuary as displayed in Figure 4d and 5d, average temperature in the estuary is 29oC and nearshore temperature is 30oC. Similarly strong stratified of pH and DO can be found in the middle and upper stretches of estuary induced by seawater (Fig 4g, 4h, 5g and 5h). Possibly, acidic water and lower DO (~ 6.7 and 3.3 mg/l) were flushed from mid estuary to upper estuary during flood tide.

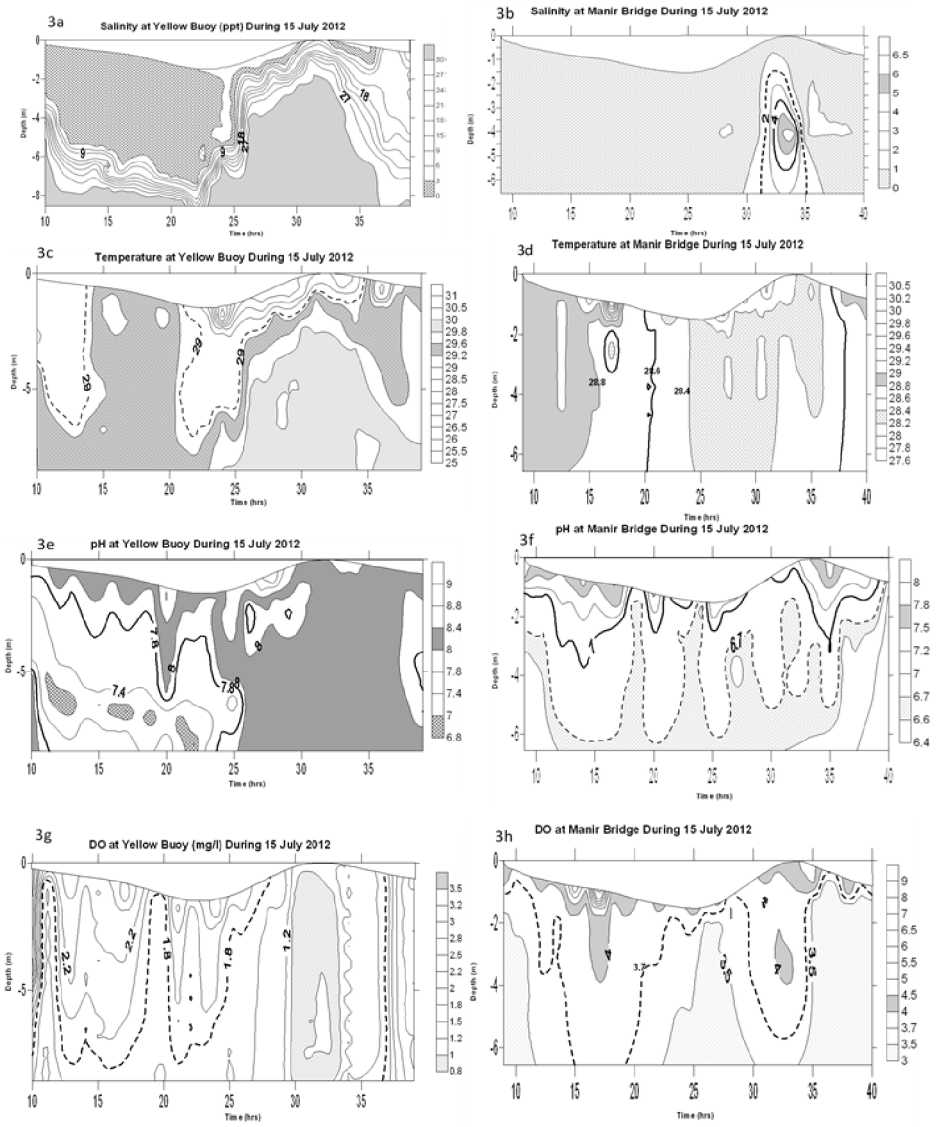


Figure 3. Water quality parameter at a) salinity at yellow buoy (YB), b) salinity at Manir c) temperature at YB, d) temperature at Manir e) pH at YB, f) pH at Manir g) DO at YB and h) DO at Manir

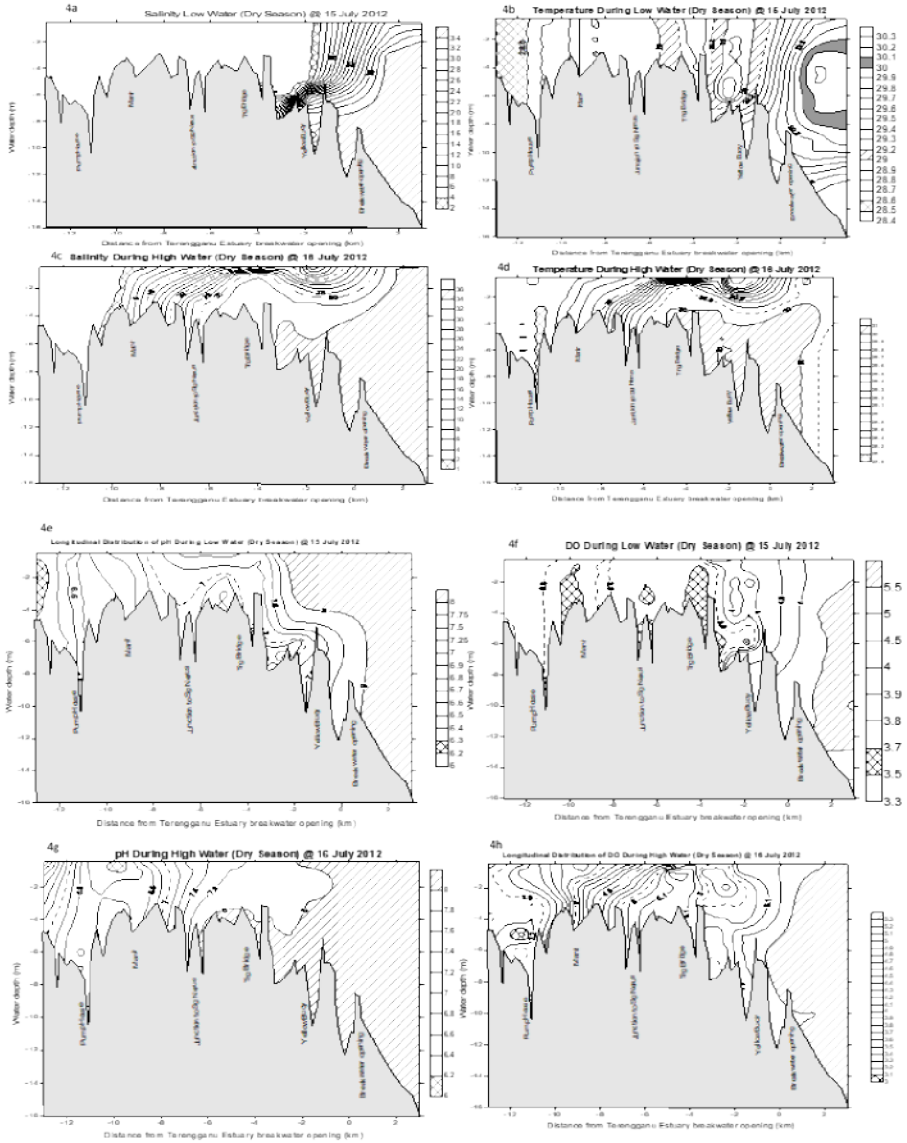


Figure 4. Water quality parameters in longitudinal axial a) salinity during low water (LW), b) temperature during LW), c) salinity during high water (HW), d) temperature during HW, e) pH during LW, f) DO during LW, g) pH during HW and h) DO during HW

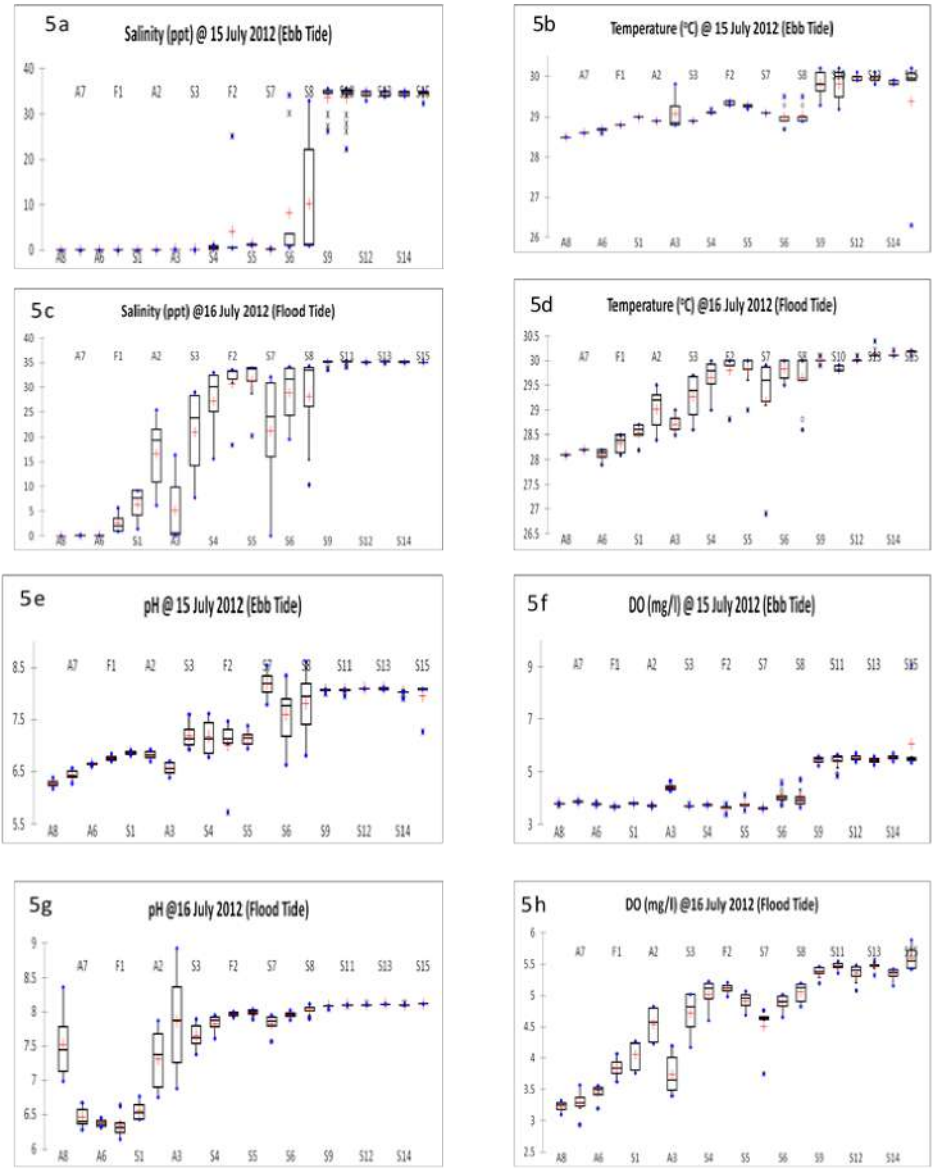


Figure 5. Water quality parameters in longitudinal axial a) salinity during low water (LW), b) temperature during LW), c) salinity during high water (HW), d) temperature during HW, e) pH during LW, f) DO during LW, g) pH during HW and h) DO during HW

Discussions

Salinity intrusion in an estuary generally depends on river discharge, sea surface fluctuations and inclination of the river bed. However river discharge and sea surface fluctuations change with time and spatial, but the bed profile is almost fixed (kasai et al. 2009). As estuary is the transitional area where fresh water meets with saltwater (Shaha et al. 2009) causing the salt wedge moved up and down the estuary (Fig 4a, 4c, 5a and 5c). The longitudinal axial of saline water conditions in Tweed, Europe and Yura, Japan estuary also affected by the river discharge and sea surface fluctuations, with drastically change between dry versus wet seasons and high versus low waters (Uncles et al. 2000; Kasai et al. 2009).

Data campaign under this study indicated that inverted water flows from lower estuary to upper estuary, causing the salt intrusion at study site of 9.5 km from the estuary with magnitude of 6.5 ppt. The main concerned is during the peak lowest flow (this area experienced 25 m^3/s, as analyzed before) and sea level rise impacts, will the saltier water travel further upstream which might affect the water extraction station at location 11.5 km from the estuary. Shaha et al. 2009 reported water is withdrawn from many rivers for irrigation and drinking purpose, however water contaminated by salt from the sea is no longer useable. The numerical model results predicted by Hong et al. 2012 expressed average salt content, salt intrusion length and stratification will increase as sea level rises. Ali et al. 2011 on the study of sea level changes along Peninsular Malaysia, Sabah and Sarawak coastlines predicted 0.273 m to 0.645 m rise of sea level at study site during 21st century.

Water temperature at lower estuary (YB) is hotter at bottom layers especially during slack high water and cooler water temperature occurs at water surface during slack low water with average density of 30°C and 25°C respectively ~~(Fig 3c)~~. Tidal and fresh water play a significant role in water temperature changes as heavier and hotter water from near-shore inflow from the bottom layers, while cooler and lighter fresh water will travel on surface. Similar condition also been reported by Vaz et al., 2005 on the temperature changes during flood and ebb tide.

Meanwhile at the upper estuary, Manir station indicates uniform water temperature distributions for the entire water bodies. Reverse condition of water temperature compared to YB station, which cooler water occurs during high water and hotter water happen during low water. Perhaps it was developed due to heat transferred by atmosphere to the shallower water (water depth about 4 m) during afternoon causing hotter water took place during low water. It agreed well with some experiment results reported by Abowei (2010) indicating some stations heats up faster due to the shallow nature of the depth.

Dissolved Oxygen (DO) in the estuary during ebb tide was significantly low in mid-estuary (Fig 4f). This was likely caused by waste effluents diverted from industrial areas and main wet market located adjacent to the estuary. As expressed by Lane et al. 2007, interaction between longer water residence time, together with low current flow and small volume of freshwater discharge during dry season, low salinities (especially less than 5 ppt (Abowei, 2010), warmer water and higher turbidity at the lower estuary (Sultan et al. 2010), causing this stretches to be bloomed with plankton, which may consume greater oxygen in the water bodies and causes the DO in the mid estuary in the ranges of 3.3 mg/l to 3.8 mg/l. Compared to the measurement took in wet season (not reported here) indicated the lowest DO during wet season was 4.8 mg/l, which is higher than dry season, it can be explained by shorter water residence time in the mid-estuary due to stronger current flow by greater fresh water volume from upstream towards seawards.

DO is vital to aquatic life as reported by Ntengwe et al. 2007 for coastal waters, the aquatic life typically required a minimum of 4 mg/l and also do better with 5 mg/l of oxygen to provide optimum ecosystem function and highest carrying capacity. Similar expression by Abowei (2010) on the oxygen depletion contributed by water pollution, such as sewage

and others waste with high Biological Oxygen Demand (BOD) are discharged into water which will deplete oxygen contain in the polluted water.

The spatial distribution of pH seems to be lower in the upper and mid estuary compared to the tidal brackish water in lower estuary (Fig 5b and 5d), with acidic water accumulated at the bottom layers. As highlighted by Abowei (2010), lower pH at the upper estuary may due to decaying of domestic and industrial waste discharge in the upstream areas contributing to acidic nature to water.

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PHYSICAL SIMULATION ANALYSIS OF SUNGAI HABU AND SUNGAI RINGLET REDUCTION OF SEDIMENTS, CAMERON HIGHLANDS

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Abstract

Reservoir numbers in Malaysia have experienced unsustainable sedimentation issue due to soil erosion induced by rapid urbanization, growth of infrastructure and unregulated agricultural practices. For an elevated pace of accumulation of water, the reservoir's estimated usable period is reduced considerably. It often limits the power generating capability of the dams which has a negative impact on the integrity of the dam and on storage of flood control. The goal of this analysis is to simulate alternate methods for effective removal of sediments in reservoir Ringlet. Construction of Ringlet Reservoir's physical sediment removal model was carried out at the Hydraulic and Instrumentation Laboratory, National Hydraulic Research Institute of Malaysia (NAHRIM), with a geometric scale effect of 1:30. Up to three different ARIs of 1, 5 and 100 were tested at Sungai Habu and Ringlet. Groyne was identified as a sediment removal control mitigation structure, and a total of 23 groynes were built. The result found that as the return duration expanded, the gross deposition and erosion areas growing. It was also observed that in 100-years ARI bed sediment was eroded even more than 1 and 5-years ARI due to local scouring resulting from the movement from fixed bed to mobile bed change. The morphological adjustments that took place at Habu was attributed to the local wind. Until the test dam, the bed sediment flow at Habu end was collected, and was not moving farther downstream. Ringlet's results showed that the sediment was deposited mostly for 1-year ARI prior to the first check dam. Furthermore, sediments can be transported for 5 and 100-years ARI and are then deposited before the second check dam.

Keywords: Physical Modelling, Sedimentation, Geometric Scale Effect, Groyne, Check Dam.

Introduction

Ringlet reservoir is situated in Sungai Bertam, in the mukim of Ringlet, Pahang district of Cameron Highlands, Malaysia (Lariyah et al., 2012; Siti et al., 2019). A huge amount of free discharges in Sungai Bertam had instigated an unprecedented rise in water level during monsoon. For many years the reservoir has experienced excessive problem of sedimentation. The issue stems from the extensive soil degradation induced by rapid urbanization, construction of utilities and unregulated agricultural activities. Studies by Adeogun et. al, (2019) and Bussi et. al (2013) showed that sedimentation that exists on the upstream of a catchment due to erosion and the loss of natural vegetation would eventually flows flood into the river and settle down at the bottom of the lake. With time, the accumulated sediment content can influence the amount of water at the dam. This will allow the dam's water level to rise (Kondolf et. al, 2014). For an elevated pace of accumulation of sediments, the reservoir's estimated usable period is reduced considerably. It often reduces the power generating capacity of the dams which has a harmful impact on stability of the dam which storing of flood control. The Tiware dam in Ratnagiri district, India, was recently ruptured due to heavy rains in July 2019. Dam-related incidents such as dam breakage or unregulated leakage of water due to a high energy level (Sidek et. al, 2011).

Since early commissioning of the dam, dredging activities have been carried out in order to retain sufficient water capacity throughout the reservoir. Nevertheless, with an improvement in the pace of deposition of sediments, the amount of dredging has risen enormously and is projected to rise much more in the immediate future and entail significant running costs. The existing sediment control and activities need to be evaluated and an appropriate and safe approach to be introduced to minimize the total cost of activity. The aim of the study is to simulate alternate methods for effective removal of sediments in reservoir Ringlet.

Methodology

Similarity Criteria for creation of physical model. The analysis of the real structure on a smaller scale is a research of a physical construct. To achieve the closes image of the real structure, the physical model must meet the criterion of resemblance. However, not all of these conditions may be met because of the dynamic interaction between the systems concerned and the restriction of the physical model. Hence, defining the dominant process involved is necessary in order to enforce the appropriate parameters and mitigate the scaling effect.

Dynamic Similitude

Dynamic similarity enables the outcomes of sample experiments to be scale-up and anticipate subsequent effects for the full-scale version. Dynamic similarity can be obtained by balancing the combination of many major forces that operate on the device. Such ratios are provided for the hydraulic system by the numbers Reynolds (Re) and Froude (Fr). Reynolds number is the ratio of inertial and viscous forces, while Froude number is the ratio of tidal forces and inertial forces. These ratios or dimensionless numbers are given by Equations 1 and 2.

$$\mathrm{Re} = \frac{uD}{v} \tag{1}$$

$$\mathrm{Fr} = \frac{u}{\sqrt{gD}} \tag{2}$$

Where u is the fluid velocity, D is the flow depth, u is the fluid kinematic viscosity and g is the gravity. Since this includes both the spatial dimension and the fluid property, it is nearly difficult to measure out these parameters. With water typically used in both model and prototype, it is possible to select only one dimensionless number, the other will unfortunately be subject to some scaling effect. For free surface flow, Froude scaling is usually taken as gravitational force is more dominant than viscous force. The scaling effect (mismatched from the Reynolds number) can be reduced considerably if there is a turbulence

flow condition.

Geometric and Kinematic Similitude

The analysis of the physical form uses an undistorted approach. This means that the scales of horizontal (X), lateral (Y), and vertical (Z) axes are similar to those of Equation 3.

$$X_\lambda = Y_\lambda = Z_\lambda \tag{3}$$

The subscript λ is the geometric ratio between the prototype and model given by Equation 4.

$$\lambda = \frac{L_p}{L_m} \tag{4}$$

Where L is reference length for the prototype, p, and the physical model, m. Based on the Froude scaling, important hydraulic parameters will be scaled as in Equations 5 to 7.

$$\text{Velocity } (u) \qquad \frac{u_p}{u_m} = \lambda^{\frac{1}{2}} \tag{5}$$

$$\text{Discharge } (Q) \qquad \frac{Q_p}{Q_m} = \lambda^{\frac{5}{2}} \tag{6}$$

$$\text{Time } (t) \qquad \frac{t_p}{t_m} = \lambda^{\frac{1}{2}} \tag{7}$$

Sediment Transport Similitude

For sediment transport, particle movement is a function of drag force and the resisting force that keep the particle in place. To obtain correct particle movement between the prototype and physical model, the sediment size need to be scaled based on the dimensionless shear stress or Shield parameter τ_* and grain Reynolds number, Re_*. These are given as in Equations 8 and 9.

$$\tau_* = \frac{\tau_o}{(\gamma_s - \gamma)d_s} \tag{8}$$

$$Re_* = \frac{u_* d_s}{\nu} \tag{9}$$

Where τ_o is the bed shear, $\gamma_s - \gamma$ is the buoyant specific weight, d_s is the particle size and u_* is the shear velocity. Based on these scaling, the following sediment transport parameters can be calculated using Equations 10 and 11.

Particle size (d)

$$\left(\frac{d_m}{d_p}\right)^3 = \frac{(\rho_s - \rho)_p}{(\rho_s - \rho)_m} \tag{10}$$

Sediment time (t_s)

$$\frac{t_{sp}}{t_{sm}} = \lambda^{\frac{1}{2}} \frac{(\rho_s - \rho)_p}{(\rho_s - \rho)_m} \tag{11}$$

Physical Model Scale

Geometric Scale

Geometric scale is an important parameter which needs to be considered for an analysis of a physical model. A large physical model is advantageous if possible, since this reduces the scaling effects and measuring error. The geometric scale considered, however, needs to take into account the total construction costs, the available space and the experiment facility efficiency.

Sediment Particle Scale

Sediment transport consistency can be accomplished if the Shield parameter without measurements and the amount of Reynolds grain between the actual model and prototype are identical. The scaling of the sediment can only be determined after an extensive site investigation data is available to determine the distribution of the grain size. While measuring particle size and density, attention must be provided to the expense and quality of the material, which is feasible locally.

Sediment Selection

The water flow in the crucial section of the reservoir was analysed using a horizontal or permanent bed model. A mobile-bed model is a model in which part of the bed consists of particles which can be transported by the flow's hydrodynamic forces. The sediments can generally be divided into two types – cohesive and non-cohesive sediments. Cohesive sediment particle is fine described as a

sediment less than 63 µm in size. Since coherent sediments are typically in suspension and need a long duration of settling, a physical model is not a viable choice to test. Many studies have concluded that cohesive transport of sediments is well suited for use in numerical models. Unless the settling of the cohesive sediment is of no interest, though, cohesive sediment may be modelled using tracer or dye in the physical model. An estimate of where the cohesive sediment is likely to settle can then be established. However, if there is little concern about the separation of the cohesion sediment, the coherent sediment can be modelled in a physical model using tracer or dye. An estimate of the location where the cohesion sediment is likely to settle can then be determined.

Non-cohesive sediment, usually large sediment and dominant bed load, is well suited for physical modelling. Recently, a site investigation was conducted to determine the distribution of grain size for the Ringlet reservoir. Based on the soil investigation report, the mean particle size at the Habu end (weir) is approximately d_{50} = 1.5 mm. Four materials are considered in order to scale the prototype sediment. They are sand (similar to the prototype), Bakelite, ABS and wood dust flour (or sawdust). In order to achieve sediment similarity, the model sediment needs to be scaled. The scaling can be done by making an appropriate selection of the density and diameter of the model material. Table 1 shows the prototype sediment diameter and density. In the meantime, Table 2 presents the density of several model sediments.

Based on the density of the model sediments, the appropriate sediment diameter can be determined by matching the dimensionless shear stress and the Grain Reynolds number between the prototype and the model sediments.

Table 1. Diameter and density of prototype sediment

	Bed Load	Note
Diameter [mm]	**1.5**	**Average particle size (D_{50})**
Density [kg/m^3]	**2650**	

Table 2. Diameter and density of prototype sediment

	Sand	Bakelite	ABS	Wood flour
Density [kg/m^3]	**2650**	**1300**	**1220**	**1100**

Methodology

General Considerations

In order to satisfy the proposed structures in the Ringlet Reservoir – simulation with first groin orientation, this physical model study was required.

Scenario flow rates

Based on the preliminary study, the maximum flow rate and corresponding prototype sediment loads corresponding to the various storm return periods tested in the physical model are shown in Table 3. As for the physical model, the scaled-down average flow rates and sediment loads are shown as shown

Table 3. Maximum prototype flow rates, Q and sediment loads, Qs for Habu and Ringlet ends

	Return period (years)	Flow rate, Q (m^3/s)	Sediment load, Q_s(kg/hr)
Habu	1	23.5	226059
	5	34.5	243597
	100	55.5	267209
Ringlet	1	7.5	91373
	5	13.4	134588
	100	23.0	193005

Table 4. Scaled-down model average flow rates, Q and sediment loads, Qs for Habu and Ringlet ends based on different return period

	Return period (years)	Model flow rate, Q (l/s)	Sediment load, Q_s(kg/hr)
Habu	1	4.7	2.1
	5	7.0	3.2
	100	11.3	5.1
Ringlet	1	1.5	1.1
	5	2.7	1.7
	100	4.6	2.4

Physical model construction

The construction of the Ringlet Reservoir Physical Sediment Removal Model took place in the Hydraulic and Instrumentation Laboratory, National Hydraulic Research Institute of Malaysia (NAHRIM). The model was constructed on a 1:30 geometric scale. This scale is the most practical scale, based on the space and facilities of the NAHRIM laboratory. The layout plans of the physical model design are shown in Figure 1.

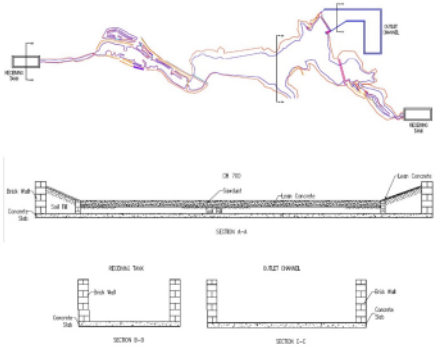


Figure 1. Physical model layout plan and cross-sections

Sampling procedure

The data collected in the study included changes in the sediment bed profile, water velocity and distribution of water velocity. The measurements were carried out prior to the experiment, during the experiment and after the completion of the experiment. The experimental procedures adopted in the present study are described as follows:

The sediment bed was contoured on the basis of the initial profile which was the level before any test was carried out. Before any test, the sediment bed was measured and recorded in the log. The pump operator then pumped water through the inlet pipes in the middle of the model. The reasons for this were to have a more stable profile and to reduce the change in bed compared to the initial profile.

Water was filled up to the maximum model level. After that, the pump was switched on until the specified flow rate for each test was achieved. The inlet flow rate was measured using Ultrasonic Flow Meter, which was installed near the Habu or Ringlet stabilizer tanks. During the measurements, the flow rate was consistent for both 1 and 5-years ARI. In the meantime, the separable flow rate for 100 years ARI has been changed to the designated flow rate based on Table 4. The sediment was then fed continuously until the end of the tests.

Result and Discussion

This segment presents the findings of Ringlet Reservoir's physical modelling research on sediment removal process. This section discusses an analysis collected from all the experiments. Up to three separate ARIs, which are 1 year-ARI, 5-years ARI and 100-years ARI, were checked with Sungai Habu and Sungai Ringlet. A total of 6 experimental runs were conducted to determine simulation output with initial groyne orientation. The data obtained from the model for both the Habu and Ringlet ends were bed profiles and flow velocity at selected chainages. Figure 2 shows a grid of 25 cm marked on each chain of the model bed to record changes in the bed profile, either deposition or sediment erosion. Measurement work shall be carried out before the start-up model operation, during the operating model and after the model operation.

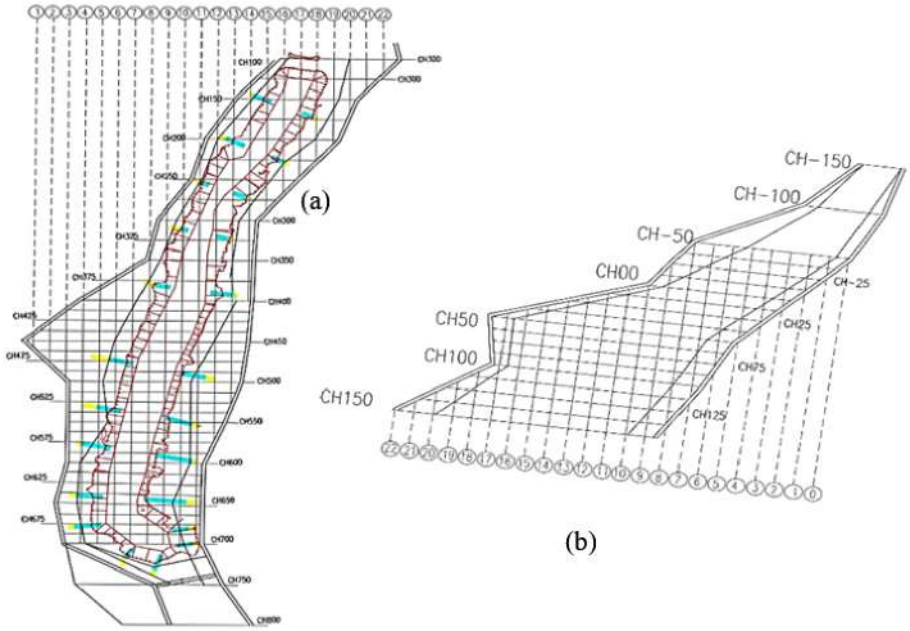


Figure 2. Grid meshes at (a) Habu and (b) Ringlet end

Habu Bed Profiles

Figures 3 to 5 illustrate the outcome of the erosion and deposition of 1 , 5 and 100 years of ARI in Habu. In this segment, the bed morphology observed at Habu covers only 3 selected chainages which are CH 700, CH 400 and CH 150. CH 700 is located upstream, CH 400 is located at channel center and CH 150 is located just before downstream test dam. As shown in Figure 5 to 7, a significantly higher erosion occurs at CH 700 as a result of the local scour induced by the exchange between the fixed bed and the mobile bed. There is not much difference between CH 400 and CH 150 pre- and post-measurement for 1, 5 and 100-years ARI.

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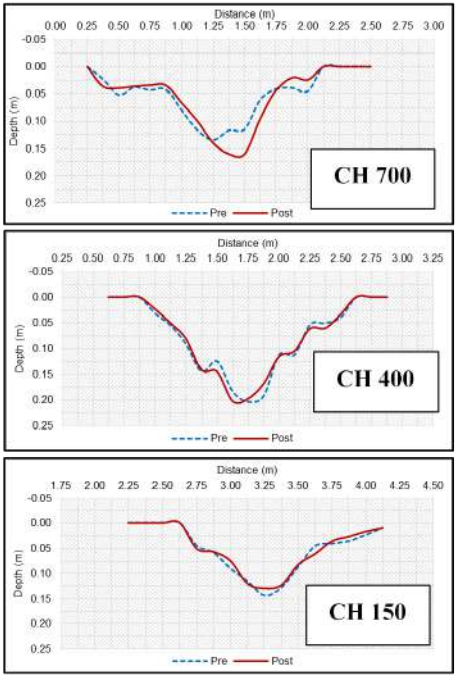
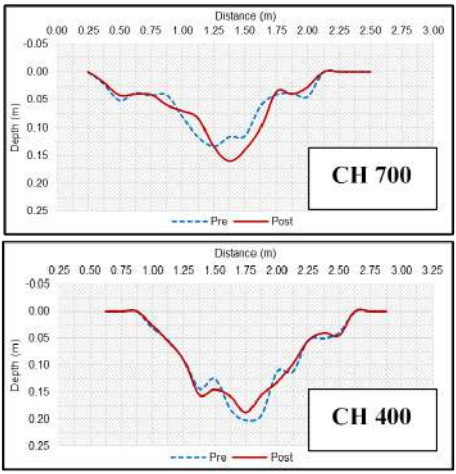


Figure 3. Cross-section of selected chainages for 1-year ARI at Habu



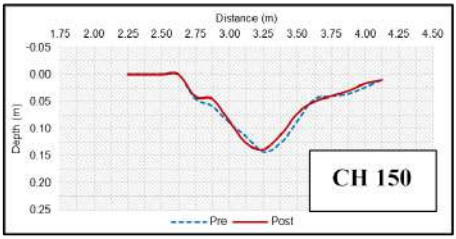


Figure 4. Cross-section of selected chainages for 5-years ARI at Habu

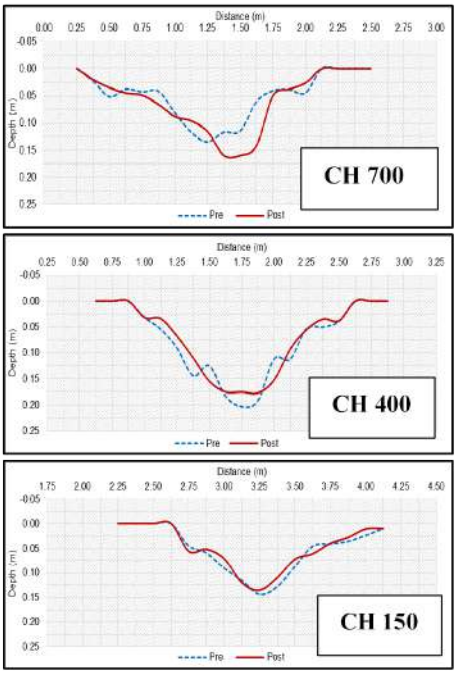


Figure 5. Cross-section of selected chainages for 100-years ARI at Habu

Ringlet Bed Profiles

In CH -37.5 for 1, 5 and 100-years ARI, it can be seen that the main process that occurs is erosion as sediment is flush into the channel due to local scouring that occurs at the bed along the chainage (Figures 6 to 8). As for CH 25, it is evident that sediment deposition and erosion occurred at 1, 5 and 100-years ARI. In the middle and right bank of CH 25, a 1-year ARI has more sedimentation, while a 5-year ARI has just deposition with no erosion occurred around the chain. As for 100-years of ARI, the flow channel sees more erosion than deposition at the left bank.

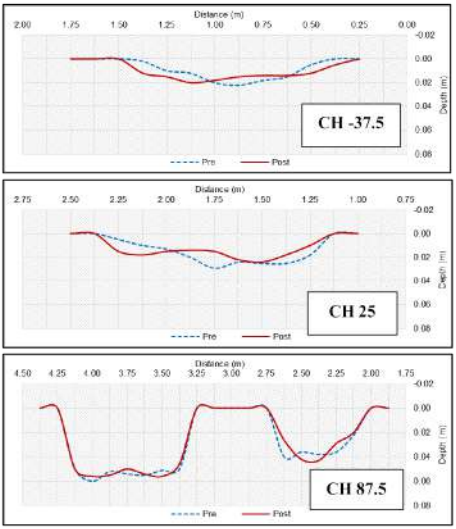
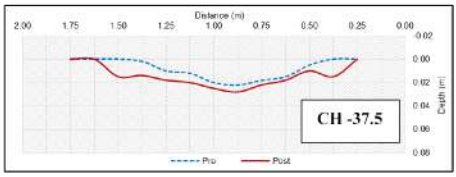


Figure 6. Cross-section of selected chainages for 1-year ARI at Ringlet



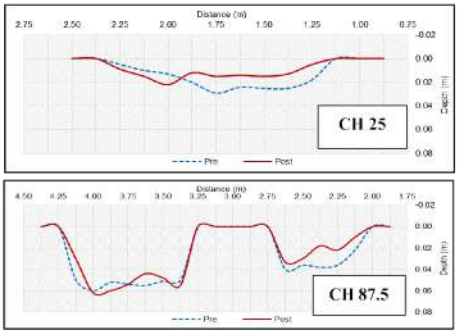


Figure 7. Cross-section of selected chainages for 5-years ARI at Ringlet

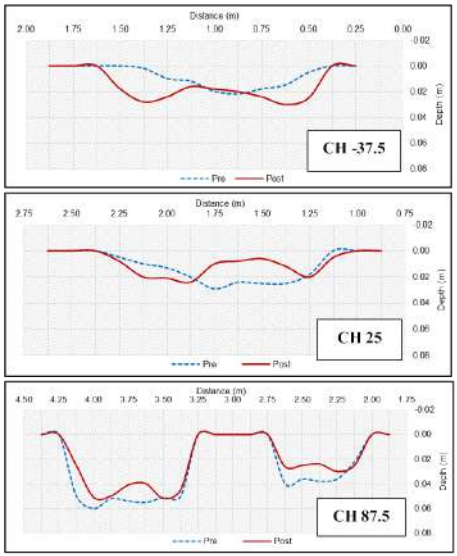


Figure 8. Cross-section of selected chainages for 100-years ARI at Ringlet

Bed Morphological Changes

The bed profile for each chainage was recorded before and after each test to observe the pattern of movement of sediments during the experiment. It can be seen that as the return duration increased, the amount of deposited bed load at the Habu and Ringlet ends was increased. The gross volume at the Habu end due to erosion, for example, is -0.1349 m^3, -0.1590 m^3, and -0.1815 m^3 respectively for 1, 5 and 100-years ARI. However, at the Habu end the gross deposition volume for 1, 5 and 100-years of ARI is 0.1516 m^3, 0.1856 m^3, and 0.2255 m^3, respectively. The volume due to erosion at the Ringlet end is -0.0234 m^3, -0.0296 m^3 and -0.0343 m^3 respectively for 1, 5 and 100-years of ARI.

Meanwhile, the cumulative sediment concentration at the Ringlet end is 0.0247 m^3, 0.0335 m^3, and 0.0451 m^3, respectively. It may be noticed that in Ringlet end the deposition and erosion of bed sediment is lower than that of Habu. The movement of the bed sediment for 1, 5 and 100-years ARI within the measurement segment is almost identical in sequence.

A previous research addressed the problem of sedimentation of the Ringlet Reservoir (Toriman et. al, 2010). Mohd Sidek et. al, (2014) and Luis Jansen et. al, (2012) estimated that, if no mitigation steps were taken, 52% of the Ringlet reservoir was already filled by sediments leaving the reservoir with a lifetime of 4 years. In contrast, at 100-years ARI the bed sediment volume is increased up to 43 percent, which has shown 9 percent difference.

Conclusion and Recommendations

A physical modelling study was conducted to simulate an alternative method for efficient sediment removal in the Ringlet Reservoir. The finding showed that the gross deposition and erosion areas increased with the increase in the return period. It was also noted that the bed sediment in 100-years ARI was more and more eroded than 1 and 5-years ARI due to local scouring as a result of the transition from a fixed bed to a mobile bed. Sediment is mostly ARI up to CH 575 for 1 and 5 years. However, the sediment may be further transported to CH 475 for 100-years ARI. The morphological changes that occurred at Habu are due to the local flow. The movement of bed sediment at the end of Habu will be deposited before the check dam and will not travel further downstream. In the case of Sungai Ringlet, more erosion is found at the flow channel than deposition at the left bank for 100-years ARI. As a recommendation, further study could be carried out by widening and deepening both Sungai Habu and Ringlet, as well as by constructing additional groin at the designated chain.

Acknowledgements

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ESTIMATION OF WATER YIELD FOR ABSTRACTION PURPOSES AT SG. GEDONG, BATANG PADANG, PERAK

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Abstract

This study was carried out to estimate water availability at Sg Gedong, Daerah Batang Padang, Perak. This study involved hydrological calculation and analysis of the historical hydro-meteorological data and water availability (yield estimation) at the project site using methods for ungauged basins. To simulate daily catchment runoff (streamflow), Thornthwaite and Mather Daily Water Balance Model was used, as described in DID's Water Resources Publication (WRP) 12. The Flow Duration Curve (FDC) was constructed using simulated daily flow data from the water balance model. It was concluded that 0.74 m^3/s (63.9 MLD) can be abstracted from the study site throughout the year during normal flow condition. However, low flow analysis frequency analysis should be also conducted to estimate extreme minimum flow associated with return period in Sg Gedong.

Keywords: Water Balance Model, Flow Duration Curve, Water Yield.

Introduction

A preliminary investigation of water availability at Sg Gedong, Daerah Batang Padang, in the state of Perak was carried out. This study aims to estimate the water availability at a hypothetical intake using water balance model with flow duration curve. As there were no streamflow gauge at the study location, the flow duration curves were calculated using methods for ungauged basin.

The location of the study site and the catchment is shown in Figure 1. The catchment area is approximately 76.6km^2. The area surrounding the study location is mostly oil palm plantations. In the upstream, more than half of the catchment is covered by forest. The climate within the basin is characterized by the Northeast and Southwest monsoon, with inter-monsoon seasons in-between. The Northeast monsoon produces the highest rainfall, which peaks in November. A minor peak happens in April, during the inter-monsoon season. The long-term average annual rainfall at Sg Gedong is 3,368mm.

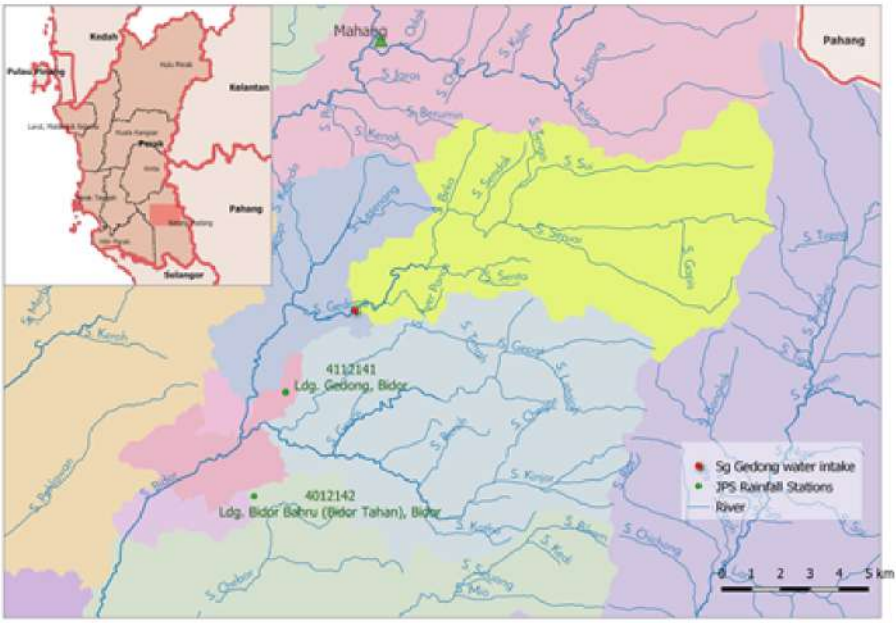


Figure 1. Location of water intake and its catchment, and the rainfall stations selected for analysis.

Methodology

There was no stream gauge at the study location. Therefore, to determine water availability at the study location, a conventional method for ungauged basins was used. Simulations of daily catchment runoff (streamflow) were carried out using the Thornthwaite and Mather Daily Water Balance Model (TM-WBM) as described in JPS's Water Resources Publication No.12, "Average Annual and Monthly Surface Water Resources of Peninsular Malaysia" (DID, 1982). The model has incorporated some modifications to the base flow and direct runoff parameters as recommended by JICA in the report, "The Feasibility Study on Small Reservoir Development in Peninsular Malaysia" (JICA, 1995). The conceptual layout of the model is shown in Figure 2.

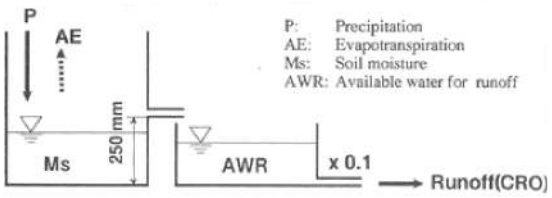


Figure 2. Conceptual layout of Thornwaite and Mather water balance model.

The TM-WBM requires rainfall data, potential evapotranspiration, water holding capacity, recession constant, direct runoff rate, and available water for runoff as input. Rainfall data was acquired from Drainage and Irrigation Department (DID). In this study, rainfall data from station 4112141 Ldg Gedong, supplemented by data from 4012142 Ldg Bidor Bahru, were chosen as input to the water balance model. The record length is 51 years, from 1961 to 2011. The location of all the hydrological stations can also be viewed in Figure 1.

The monthly potential evaporation data was taken from WRP 5 (DID, 1976), Tapah (5000413) station. The rest of the parameters are determined in accordance with WRP 12 (DID, 1982). The results from the simulated daily runoff were used to produce flow duration curve (FDC). The FDC is basically a cumulative frequency curve which shows the percentage of time a flow value of a specific duration is equalled or exceeded within the period of record. It is a conventional method to assess the availability of water from river flow. The 95 percentile flow (Q95), which is the flow exceeded for 95% of the time, usually represents the amount of flow that can be abstracted from a river without adverse impact to river ecology. In this study, FDC was produced from the daily flow generated from TM-WBM to determine the Q95 flow value.

Results

FDC was produced from daily flow values simulated by TM-WBM for Sg Gedong, as shown in Figure 3 and Table 1. The FDC shows that the river is perennial with sustained baseflow throughout the year. The low variability indicates a permeable catchment, which is consistent with satellite imagery view of the catchment showing that more than half of the catchment is still forested.

Based on the FDC, the Q95 value is at 0.74 m^3/s (63.9 MLD). The water management rules defines Q95 as the acceptable flow to be abstracted. In the UK, the Q95 is the 'hands-off flow' (HOF), which is the amount of flow in the river below which abstraction works should be stopped (Barker and Kirmond, 1998).

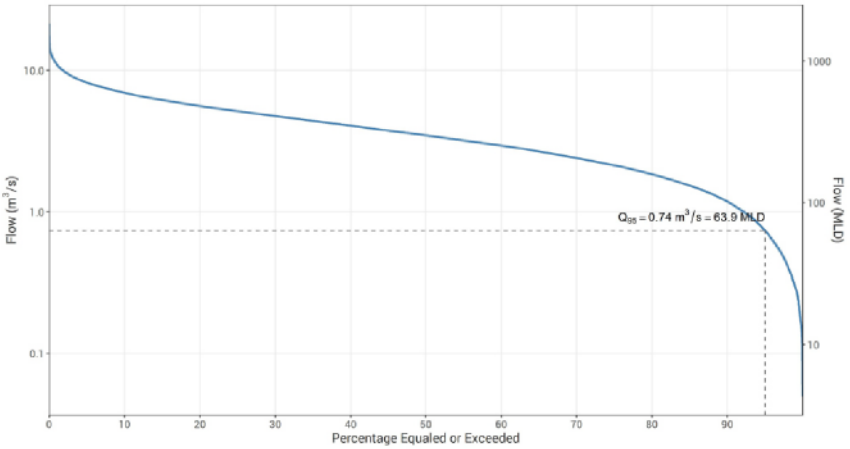


Figure 3. FDC produced from WRP 12 daily water balance model showing Q95.

Table 1. Exceedance Frequency (%) of flow (m3/s).

Percentage	0	1	2	3	4	5	6	7	8	9
0		11.04	9.84	9.09	8.59	8.19	7.88	7.61	7.38	7.15
10	6.95	6.77	6.59	6.43	6.30	6.17	6.05	5.94	5.81	5.71
20	5.60	5.50	5.41	5.32	5.24	5.15	5.07	4.98	4.91	4.83
30	4.75	4.68	4.61	4.54	4.47	4.39	4.33	4.27	4.20	4.13
40	4.07	4.01	3.94	3.87	3.81	3.76	3.70	3.64	3.58	3.53
50	3.47	3.42	3.36	3.30	3.25	3.19	3.14	3.09	3.04	2.99
60	2.94	2.89	2.84	2.79	2.73	2.67	2.62	2.56	2.51	2.45
70	2.40	2.35	2.29	2.24	2.19	2.13	2.08	2.02	1.96	1.91
80	1.85	1.79	1.72	1.66	1.60	1.54	1.47	1.40	1.34	1.26
90	1.18	1.10	1.02	0.93	0.84	0.74	0.63	0.53	0.41	0.29
100	0.05									

Conclusions

It was concluded that 0.74 m3/s (63.9 MLD) can be abstracted from Sg Gedong study site throughout the year during normal flow condition. However, further analysis should be conducted using low flow frequency analysis to estimate extreme minimum flow associated with return period in Sg Gedong.

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THE IMPORTANCE OF HYDRO MECHANICAL RESEARCH AND DEVELOPMENT FOR SOLUTION

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Abstract

The importance of the principles of sustainable development is increasing in the development of hydro mechanical and electrical engineering. Most projects or developments rely on hydro mechanical functionality to complement a system. There are many categories of hydro mechanical including hydro mechanical for agricultural drainage, hydro mechanical for water supply, hydro mechanical for water disaster, hydro mechanical for generating power electricity and more. Besides, most of the research and development is designed in line with hydro mechanical scale in direction of environment protection from pollution and worst case scenario.

Keywords: Mechanical engineering, sustainable development, electrical engineering, project cycle, environment

Introduction

There are many resources could be harvest from the environment include hydraulic resources. The energy sources of hydraulic are not just from surface water such as river water, lake water and marine water, but it's possible could be a part of the environment such as water falls, digestion, heat transfer and more. The hydraulic energy resources could be potential from wastewater, sewage, rain water and thermal water (Augusto et al., 2009). The conversion process required hydro mechanical approaches step by step. The hydro mechanical had evolved from ancient times to modern times.

Along 11th. Malaysian Plan, hydro mechanical research and development had contributed water to energy conversion through bio digester system, ram pump system and rain power apprentice using piezoelectric concept (Dewi & Andang, 2010). Others hydro mechanical research and development are bio flocculants lake water treatment system, auto sand filtration for lake water treatment, de-sludge pumping system, solar pumping system for lake water circulation, micro aeration system and rain water harvesting filtering system (Mashhadi et al., 2016). In line with hydrodynamics parameters such as ocean wave or current, river flow rate or velocity, waste water characteristic, fluid density and others environmental natural resources, many application of mechanical concept could potential been involved from apprentices' scale

to real commercialized scale (Rashwan et al., 2003).

River flows potential created energy and ocean wave also potential created energy by applying the concept of kinetic conversion and pressured conversion by mechanical design medium producing continuous energy (Taylor, 2014). Hydrokinetic energy from flowing water in open channels has the potential to support local electricity needs with lower regulatory or capital investment than impounding water with more conventional means (Taylor et al.,2012). Electricity rates are on the rise and electricity usage is increasing following the changing lifestyle of the community along the coast and along the river. Whereas in some places such as Pulau Tinggi in Johor, there is still no electricity supply as it is located far from the country's electricity supply grid (Wang et al., 2007). Contaminated water from rice husk, sewage and food waste is increasingly contributing to the release of methane gas which contributes to the impact of climate change. Some of the hydro mechanical research programmed had been done for energy harvesting since 2015 at Hydraulic and Instrumentation Laboratory (Yakout et al.,2015). It's had been continued along 11th. Malaysian Plan until 2019 in upgrading hydro mechanical design, develop and at different sites study. The objectives of the hydro mechanical research and development is to produce innovation solution in order to assure sustainable development growth (SDG) encountering the climate change impact for the community of coastal line, river bank and remote area.

Material and methods

Hydraulic and Instrumentation Laboratory had conducted some categories of apprentice hydro mechanical studies, which are: (a) renewable energy harvesting from wastewater; (b) renewable energy harvesting from rainwater power system; (c) renewable energy with coastal waves interaction using N-CODE innovation products; and (d) renewable energy harvesting by river flow interactions using NPMH.

Results

Results of pilot study of renewable energy harvesting from contaminated wastewater based on bio digester concept.

Many type of wastewater could be a sources to bio digester processed. Some study had been mad to design and developed NAHRIM Innovative Bio Digester System (NIBS) where using zoo animal waste and sewage as in Figure 1 and Figure 2. Both design had performed less than 12 Volts power generation in short of time. The accessed of waste scheduled had contributing a generation performance of both NIBS design. One of the lack of the design is segregating low and optimum quality of waste which produce methane gas as fuel burner.

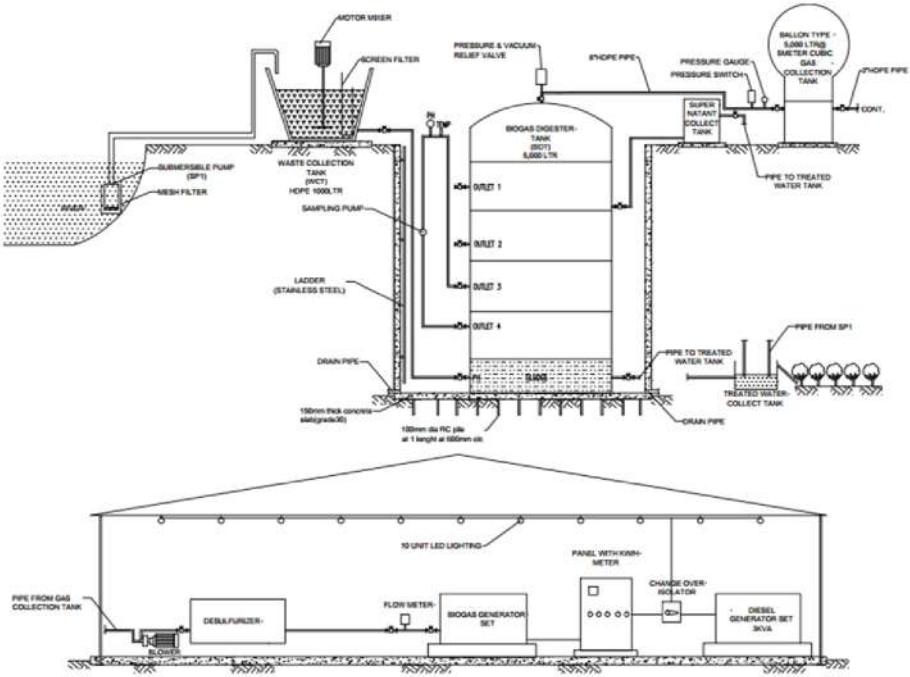


Fig. 1. Design of the development of NAHRIM Innovative Bio Digester System (NIBS) Using Zoo Animal Waste

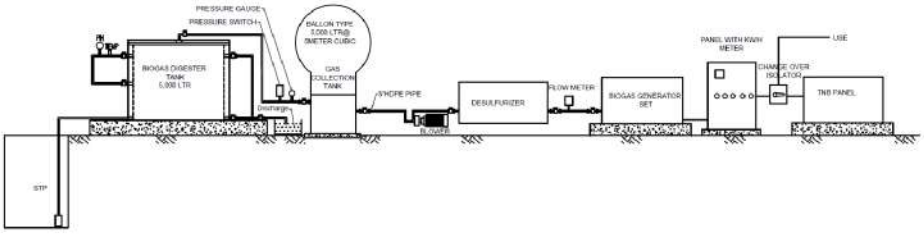


Fig. 2. Design of the development of NAHRIM Innovative Bio Digester System (NIBS) Using Sewage.

Results of pilot study of renewable energy harvesting from rainwater power system

Laboratory tested design had found that the rain droplets could possible generated power at small amount. The capacity of the energy harvesting is according to the size of piezoelectric plate size. However, further study shall be done for having long period of droplets in order to have continuous energy harvesting. Figure 3 is the laboratory testing for the simulation of rain droplets.



Fig. 3. A Hydro Mechanical Design For Rain Water Droplets Toward Piezoelectric Plate.

Results of pilot study of renewable energy with coastal waves interaction using N-CODE innovation products.

The N-CODE design had been laboratory tested and site tested, performed stable in power generating for in period of the high tide for about 8 hours in a day. The maximum power generated at average of 4 Volts at constant wave height.



Fig. 4. A real design of N-CODE tested at Pulau Tinggi, Johor

Results of pilot study of renewable energy harvesting by river flow interactions using NPMH

The NPMH design had been study since 2019 for the first model. The first power generated at average of 3 Volts at constant river velocity tested at Hydraulic and Instrumentation Laboratory. This design is capable too

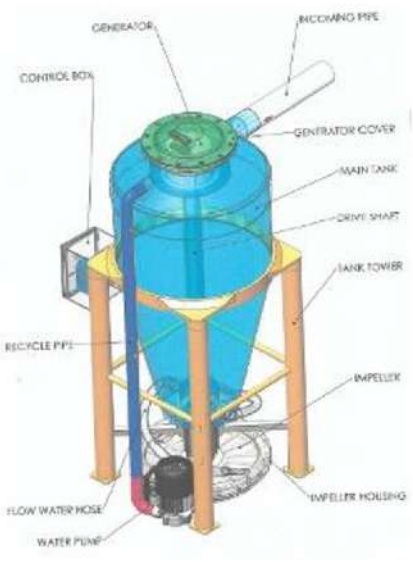


Fig. 5. A fundamental design of NPMH Version 1.0

Discussion

In this study, few designs had been tested in order to see the energy harvesting concept from NAHRIM Innovative Bio Digester System (NIBS), Rainwater Power System (RPS), NAHRIM's Coastal Defense and Energy Generator (N-CODE), and NAHRIM's Portable Mini Hydropower (NPMH). In terms of time of testing, further procedures had to be impose for long terms result for establishing performed designed. From all the hydro mechanical design, some findings meet the objectives whereas NIBS shows that waste could generate electricity, N-CODE could have harvested energy from the movement of ocean wave, NPMH could harvest energy from the river velocity and RPS at large size could possible harvesting electricity from the rain water droplets.

The hydro mechanical design is much depending on hydrodynamic characteristic. N-CODE which design for ocean energy harvesting depend much on tide period. Different to NPMH whereas according to river flows at every second. The RPS is too much depending on rain period. However, the sources of water droplets could be extending to the sources of waterfalls droplets which drop every second. The NIBS performance is too depending on biological period whereas production of methane as combustion gases according to both aerobic or anaerobic digestion. All study shows that hydrodynamic factors plays significant influence factors for any hydro mechanical design product. Further studies related to hydrodynamic factors at laboratory testing area simulated and at real site test area for 365 days or more could performed stable hydro mechanical innovative product design.

Conclusions

There are so many further study for innovation design improvisation. However, along 11th. Malaysian Plan, most innovation had just begun design conceptual and small scale apprentice application. Medium and long terms resources with knowledgeable collaboration could possible fine tuning improvement in method of testing scenario for both physical and numerical testing.

Continuous hydrodynamic consideration shall be a database for enhancing hydro mechanical research and development. Real on site testing had been found contributing the significant findings and results of performance and require hydro mechanical testing procedures.

In design hydro mechanical, automation could possibly be applied in the process of routine feeding of the agricultural waste similar to the sewage drainage system from residential to the integrated sewage treatment plant with a biodigester operational system. Further study could possibly on the evolution of industrial revolutionary (IR) from IR3.0 to IR4.0 and beyond.

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STRUCTURAL AND NON-STRUCTURAL WAYS OF MANAGING FLOODS WITH RESPECT TO CLIMATE CHANGE SITUATION

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Abstract

Flooding is historically a major environmental problem in many parts of the world. Malaysia is one of those countries that frequently experiences flash and regional flooding due to geographical location, topography, climate and the improper development activities. Appropriate flood management measures need to be put in place to reduce negative flood impacts. Such measures can be categorized as structural measures and non-structural measures. Numerous structural and non-structural flood management already being introduced for example dams, levees, floodways, flood wall, river improvement, education, public awareness, flood warnings and many more. Such measures are intended to reduce the frequency and amount of damages due to flooding. Climate change and global warming are aggravating the flood impacts on the society and environment. As such, this paper is intended to review the flood management techniques already being implemented around the world and their suitability with respect to the climate change that already has happened and might happen in the future. This paper discusses the past, present and future perspectives of managing floods through structural and non-structural techniques. The advantages and disadvantages of such methods on the people, community, economy and the environment under the climate change situation are also attempted to be evaluated.

Keywords: Climate Change, Safety, Structural, Losses, Non-structural, Flood Disaster, Flood Management.

Introduction

Of all natural hazards, floods are to be blamed or the greatest economic damages in the world (Thieken et al., 2016). Estimates show that more than 65% of the world's land mass and 196 million inhabitants are vulnerable to devastating worldwide floods (Abbas et al., 2014). On the other hands, the country is currently experiencing an increasing rate of floods due to the trend of climate change contributing to irregular monsoon patterns. The climate change results in shifting levels of precipitation and regular disruption to flooding. In the future, climate change will lead to a rise in flood damages in several areas due to an increase in flood levels and magnitudes. Nonetheless, climate change effects may vary from catchment to catchment. Therefore, flood mitigations are needed to reduce the danger from flood events for people living in flood-prone areas. The flood mitigation includes structural measures such as dams, levees, floodways, flood wall, river improvement and non-structural

measures such as, education, Integrated River Basin Management (IRBM), public awareness, flood warnings and many more. The aim of the present paper is to address the structural and non-structural measures established over the years in few countries to protect the agglomerations from flooding with respect to climate change situations. The structural and non-structural measures are to be evaluated for each case study. Eventually, several observations will be offered as well as further suggestions to be implemented in Malaysia.

Climate Change and Flood Mitigations

These are some of the key ways that climate change raises flood hazards. Heavy rainfall does not contribute to flooding immediately, but it does increase their ability. Somehow, even moderate amounts of rainfall may cause severe damage, especially in areas where urbanization is growing. Experts estimate that climate change has increased the likelihood of precipitation three times, perhaps 15 times higher (Denchak, 2020). Besides, when ocean temperatures increase and glaciers and ice sheets melts around the world due to phenomena worsened by climate change, global sea levels rise. The rise in sea level raises high-tide flooding, which has increased over the last 30 years and is expected to more worsen in the coming decades. The floods can overturn someone lives and gave both short and long term consequences when a house or neighborhood is inundated by flooding. The most obvious one entail loss of life and severe damage to property. Hence the mitigations of the floods are very important.

Winter snow melting in spring is always a time of high river flow, and river channels form themselves in many areas to handle these regular flood events by constructing banks and slowly increasing flood plain terraces in reaction to the high water each year. For decades, afforestation, reforestation, and forest restoration have been advocated as key mitigation solutions for the climate change (Şen, 2018). The plants can hold the ground moist and helps protect it from heavy rain and serves as a reservoir that can protect from flooding. Furthermore, green infrastructure, an integrated system made up of natural or man-made open space and design elements can provide advantages for multifunctional ecosystem services, has been described as a crucial tool for both climate change mitigation and adaptation as well as combating climate justice in local communities (Cheng et al., 2017). Nonetheless, the scarcity of data on climate change has prevented smaller communities from continuing to pursue climate change adaptation initiatives.

Case Studies

Many flood studies in the world used the typical structural and non-structural solution as the flood mitigation to mitigate the flood as instance dams, levees, floodways, flood wall, river improvement, flood warning and many more. Apart from these few case studies from other countries where they used others flooding techniques. This study also includes a detailed assessment of structural and non-structural flood mitigation as well as analysis of flood-related research conducted in Malaysia, South Korea, Hong Kong, Japan, Australia, Thailand and Indonesia.

Case Study: Malaysia

In Malaysia, although Malaysia located in a severe 'catastrophe-free' and geologically stable area, occurrence of floods has become an annual event. Of all the natural disasters in Malaysia, floods are likely the most severe and inflict the greatest damage every year especially during the end of December. Studies by Yusoff, Shafii, & Omar (2017), Malaysia need for catastrophe management preparation was established for both the structural and non-structural approaches. Both practices both structural and non-structural control approaches are aimed at reducing the effects of flooding.

In 1982, Malaysia government have

conducted a National Water Resources Study on structural and non-structural measures for flood mitigation and management (Department of Irrigation and Drainage Malaysia (DID), 2010). Subsequently, variety of flood mitigation measures have eventually undertaken, such as river canalization, river embankments, dams and many more. On the other hands, DID already has step up on their flood forecasting and warning system. The infrastructure for flood forecasting and warning system equipment currently built are:

- 233 telemetric rainfall stations;
- 190 telemetric water level stations;
- 256 manual stick gauges;
- 84 flood warning boards;
- 217 flood sirens;
- real-time flood forecasting and
- warning systems in nine river basins.

DID also has set up an Internet-based National Flood Monitoring System known as Infobanjir (http:/infobanjir.moa.my), through which data on rainfall and water levels can be obtained for the entire country to keep the community aware of the flood news around them.

The benefits of these non-structural measures are their complement to the constraints of implementing and operating the structural measures. It can also create people's awareness and acceptance of flood occurrences and increase preparedness prior to the disaster.

Case Study: South Korea

A study of the effects of climate change on the Korea peninsula that raised incidence of severe rainfall frequency, including typhoons, intense heavy rainfall that persisted for a relatively long time that causes the flood damages. The government in South Korea has developed the "Comprehensive Flood Prevention Plan for river Basin (CFPPB)" for each river basin to combat flood (K. Kim et al., 2019). The CFPPB takes a comprehensive approach to basin service by connecting natural and artificial structures as instance dams, retention pond, flood control system, flood road that can restrict water flows in order to strengthen the ability of the basin to deter floods. The CFPPB is designed to protect people's lives and properties by appropriately spreading flood discharge within the basin and improving the ability of flood control systems to mitigate flood damage.

A research by Kim et al., (2019) is being undertaken at the Anyangcheon stream to mitigate flood discharge in the main stream by installing a combination of structural flood measurements. The flood measures are reservoirs, floodgate, river improvement and floodway. The types of combinations of flood mitigations depend on the region classifications. Classification refers to having things divided into similar groups or types. Diverse guidelines have also been used to identify flood-prevention measures. The measure classified not only by its structural or non-structural criteria but also by the characteristics of the measure. Depending on their defensive purposes, groups were divided into three groups (water control measure, land use control measure, and financial relief and loss reduction). The advantage of this scheme is it improves the river channel of Anyangcheon stream. Nonetheless, the construction costs will be higher because the measures require more than two measures in one area.

Seoul aims at improving the old way of focusing on physical extension of the infrastructure and engaging the general public in the creation of disaster management strategies adapted to local needs. The development of low-lying areas and lower-income housing for urban residents has left some 40,000 households at risk of flooding. In order to mitigate floods in vulnerable low-lying basin areas such as Shinwol (Yangcheon) and Hwagok (Gangseo), rainwater collection, drainage facilities, installation of flood gate and other required infrastructure were installed based on input from both experts and residents (Y. R. Kim, 2011).

Case Study: Japan

Japan's island sits in the northern hemisphere also known as Temperate Monsoon

Asia. Seventy percent of Japan's land surface is covered by fairly steep mountains, mostly volcanic. The landmass is geologically unstable. Because to its location, Japan usually suffers from local downpours caused by baiu-zensen (seasonal rainfront) and typhoons in summer. In the winter, whipping northwestern winds from the Asian continent make the coastal area by the Japan Sea some of the snowed regions of the world. Due to that, topography and climate greatly affect the rivers in Japan.

One of Japan's flood mitigation schemes is to take comprehensive flood control measure in response to surface water runoff increasing volume and faster pace due to rapid urbanizations. This measures are applicable to rivers at the top three urban centers and small to medium-sized rivers, which are rapidly growing urban areas without appropriate flood control measures (Mochizuki & UEDA, 2012).

The Japan government has constructed a complex, massive structure under the city to deal with the earthquakes and 'guerrilla storms' (Dunlop, 2015). Tokyo is lined by several canals and waterways, and the canal walls are now reinforced and each side has large slopes. Figure 1 shows the massive pillars of Tokyo metropolitan area underground flood discharge tunnel. In the last one hundred years the discharge from these streams and canals has increased. Flood gates were designed to help over in diversion and flood control, as the capacity to retain water due to consequence of urbanization is much less.

The tunnel itself cost around $2 billion to build. Tokyo's full flood protection program is a masterpiece in engineering and a regional trailblazer in coping with flooding especially in fast-growing metropolitan areas. Continued urban expansion, the latest upsurge of storms across East Asia and the likelihood of further climate change adjustments have troubled city planners. Particularly when it seems the system in some areas is being overwhelmed.

Case Study: Hong Kong

Meanwhile in Hong Kong, with the comprehensive flood prevention strategy in place, the Hong Kong Special Administrative Region (HKSAR) Government is on its way to providing an adequate level of flood protection



Figure 1. Underground flood discharge tunnel in japan (source: BBC Future)

and promoting sustainable development for the benefit of the community. This flood management was built to match Hong Kong's specific conditions, which exhibit flashy flood characteristics in nature and blend with dense urban areas under extreme land development pressure (Chui, Leung, & Chu, 2006). The political pressure for flood risk management is strong, and the city can expect significant financial spending in structural measures.

To tackle severe flooding, a number of schemes were initiated by the Retention Services Department of Hong Kong to increase water drainage in the area. Instead of constructing irrigation systems in flood-prone areas, the city intercepts and diverts rivers along its natural courses in order to better prevent flooding. Hong Kong has built 2,400 kilometers of stormwater drains, 350 kilometers of river channels and three underground flood storage tanks containing a total of 17,000 m3 (Cities 100, 2015). The strong drainage system of the region not only decreases flood risk, it also revitalizes water bodies and builds green spaces, which in turn encourages biodiversity and mitigates the impact of heat in Hong Kong.

Case Study: Australia

Summer 2010–2011 saw major flooding in Australia, caused by a heavy La Nina phenomenon, similar to previous severe flood events in 1974 and the mid-1950s (Bureau of Meteorology, 2011). Many participants are engaged with flood risk reduction in Australia that includes all three levels of government, the State Emergency Service, SES and other emergency response organizations, the

insurance industry, catchment management authorities and local communities (Box, Thomalla, & Honert, 2013). In Australia, land use and hazard management are the primary focus of their flood mitigation preparedness. The implementation of a policy allowing the elimination of incentives for projects constructed in areas with at least 1 in 100 possibilities of floods each year and the flood mapping are required for those areas. One of the earliest example of official acknowledgement of them dealing with flooding was a flood in Windsor, west of Sydney after the Governor of New South Wales, criticized the migrants for residing in established flood areas and encouraged them to relocate into surveyed townships (Low, Avery, & Gillespie, 2007). At least two towns were fully evacuated due to floods which are Gundagai, New South Wales and Clermont, Queensland. This promotes the development and implementation of effective flood risk management policies so that the current community is more responsive to floods. Besides it encourages the community to respond and recognized the flood behavior and how dangers are addressed to the community.

Case Study: Thailand

In Thailand, rivers and water resources reflect not only the economic value but the nation's intrinsic traditional way of living, cultural heritage and long established culture. Alongside that, Thailand also has experienced severe flooding. The current flood risk management strategies and practices in the country are inadequate, particularly with regard to the restrictions on community involvement. They were applied in a passive manner, emphasizing preventive measures and emergency response to flooding incidents. Their mitigations plans are more focus on the Chao Phraya River Basin, Thailand that they prioritize on structural measures and also passive responses to the floods. The plan includes feasibility studies and short-term (2015 – 2016) environmental impact evaluations, and medium-term (2017 – 2021) and long-term (2022 – 2026) mega-project projects as instance water pipelines or dikes (Singkran, 2017).

One of their exiting adaptive flood mitigation solutions to 2011 floods is the dikes built in urban areas alongside the Chao Phraya river where the structure's height is 1-2 meters as shown in Figure 2. This offers the river scenery restriction at normal times, due to the dike's height. Even so, several local communities that lives on the sides of the Chao Phraya River in the province of Ang Thong, have requested to the local government to remove the flood control dikes across their regions where they claimed that they were hidden by the height of the flood control dikes from nature and feel like they were living in confined areas (Thiprut, 2016). This is primarily the community's problem per se.

They also focus on non-structural flood mitigation, where they have already developed emergency response to the community before flooding happens. Community participation in emergency response is another important contributing factor, especially during flood evacuation. It can provide the society an idea of what to what to do, what to do, how to do and where to escape in the case of a flood.



Figure 2. The dikes alongside of the Chao Phraya River

Case Study: Indonesia

Indonesia is significantly more vulnerable to flooding events, compared to other countries. It ranks third and seventh in the world in terms of flooding and the number of affected people, respectively (Hapsari & Zenurianto, 2016). The climate in Indonesia is same with Malaysia, where it is mainly tropical with two separate monsoonal wet and dry seasons. Because of that, it is highly prone to flooding due to the wet season during November until end of March.

Several recent efforts have been made to mitigate the wide range of flood issues through local structural measures. For example, land use spatial planning in the Jakarta Flood East

Canal Project, integrated water resource management by the Brantas River Basin authorities, appropriate coastal flooding in the low Semarang district, and relocation of river squatters in the Solo River (Hidayat et al., 2008). In addition, the government also focuses on improving the river, but at the same time protecting the riparian areas and raising awareness for the society that resides in the area. Throughout this regard, the concept of improving the river which aims to bring the river back to the natural states is advocated rather than the concept of river engineering. Instead of growing the channel size, the standardization of the river is carried out not only to provide but also to provide a larger riparian zone for environmental protection and also to reduces the bottleneck.

Discussions

Based on this three case study; Japan, Korea and Hong Kong, they are more focusing on mega structural flood mitigations which is flood diversion and canalization. Malaysia also has a parallel mega-structure flood drainage tunnel called Stormwater Management and Road Tunnel, SMART tunnel that addresses the flood issue in the middle of Kuala Lumpur. However, problem with SMART Tunnel, during the flood season it is not actually helping with the traffic congestion. Often it is the mega-projects to build infrastructure for people that offer the most bang for the buck in the face of the insurmountable debts that legendary projects may face. But in spite of the advantages they offer, there is still a reason for those initiatives.

Plate (2002) recommends that flood risk to vulnerable area should be reduced by relocating the buildings or accommodation outside the flood plain as implemented by Australia governments. Having mentioned many studies seeking to reduce flood impacts, they point out that multi-method flood reduction is considered the best way as it is one of South Korea's best practices. Even so, climate change will have significant environmental impacts, especially in developing countries as they have fewer resources for social, technological, and financial adaptation. For mitigations, there are many suggestions on the ways to reduce flood, many people think removing people from the flood prone zones to a place with high elevation is the best way of mitigation. Therefore, the best mitigation is to stay away from low elevation areas and engage in emergency awareness. But its only save the people and community of the area not the place itself.

At the same time, public awareness regarding flood hazards should be introduced. This has already been applied in their country by most area of study. Informal contact is also one of the most common, relevant and effective ways of acquiring knowledge regarding flood protection. It is therefore possible to organize advertising based on interpersonal communication and supplemented by a variety of mass media. Reliable flood forecasting and alerts can help by alerting the community, rather than simply responding to the crisis.

Conclusions

Flood protection measures do not guarantee complete safety. Catastrophic floods can cause serious damage and can impact the national economy. Adequate flood protection cannot be accomplished in many vulnerable areas with the assistance of structural means alone. Consequently, further reduction of flood risk via non-structural measures is often essential. The flood danger risk assessment is performed to determine the exiting vulnerabilities and ensure the best elements needed to reduce the impact of the flood hazards in Malaysia. This seeks an optimum, site-specific combination of structural and non-structural flood mitigations. Besides, the community that lives in flood areas also needs to live with awareness of the possibility of flooding. While we cannot prevent the occurrence of natural disasters, early warning systems and a well-organized disaster management plan can lessen the disruption. Ultimately, a multidisciplinary strategy should be followed which involves a well-balanced mix of structural and non-structural interventions. In this context, the use of legislation to regulate floodplain encroachment, hill land development and urbanization is crucial if Malaysia is to grow efficiently at a sustainable pace, thus maintaining and sustaining its ecosystem, while at the same time effectively controlling flood hazards.

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IDENTIFICATION OF SEA WATER INTRUSION IN COASTAL AQUIFER OF TUMPAT AREA, KELANTAN USING ELECTRICAL RESISTIVITY IMAGING AND GEOCHEMISTRY METHODS

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Abstract

The present research focuses on seawater intrusion into groundwater in parts of Tumpat. Tumpat is to known city near to the shore line which is famous for coastal activities. Geologically the area is mainly comprised of quaternary alluvium all along coastal areas. In present study the integrated approach is applied using Electrical Resistivity Imaging (ERI) for 200 meter line and data collected using ABEM Terrameter LS with 42 electrode, 5 meter spacing and data process using software RES2DINV. The chemical methods which include insitu test (Salinity, TDS, TSS, Turbidity EC and pH) and laboratory experiments such as AAS and titration for chloride concentration in five well locations. Total five survey lines were conducted by applying Pole dipole and Wenner configuration. Based on resistivity profile, all five location of survey line showing seawater intrusion at approximately 30 meter depth. From the insitu chemical result, location 1 shows high salinity value owing to the proximity of the location near to the shore line.

Keywords: Seawater Intrusion, Resistivity, Chemical Parameter, Tumpat, Kelantan.

Introduction

Groundwater resources become demand of people living in Northern part of Kelantan. However, there are various groundwater pollution might affect health of them. The most crucial problems including seawater intrusion within groundwater aquifer. In coastal area, saline invasion is commonly happen and become major problem [1[.The present study for identify seawater intrusion was done by both geochemical test and geophysical survey in parts of Tumpat, Kelantan (Fig 1). Electrical Resistivity Imaging (ERI) is used to identify saltwater intrusion. The salinity sources and water intrusion easily identify by using geophysical and geochemical.

Saltwater intrusion study take place in Tumpat town along with neighbouring location. There are five selected location for geochemical test and another five selected location for ERI survey along the shore line. This research is important for the people especially who are using groundwater as the main source of water. Peoples who is living in Northern part of Kelantan totally depend on groundwater for daily uses [2] and mostly using open well or dug well.

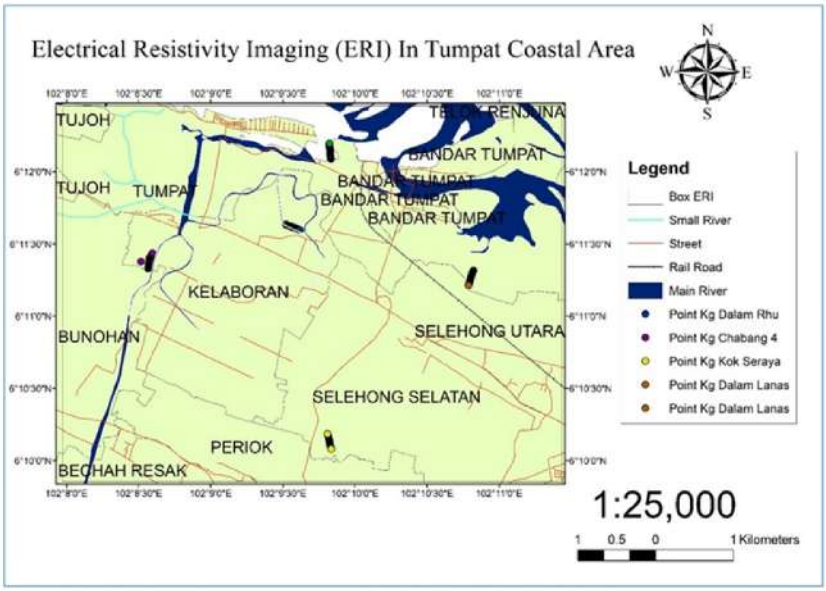


Fig 1. Sampling location map

Materials and Methods

The integrated method were used to determine groundwater quality and pollution. There are Electrical Resistivity Imaging (ERI) and Geochemistry. By combining these two methods, saltwater intrusion can be analysed accurately.

ERI method is beneficial because it can provide data beneath earth surface. For these survey. There are total five line survey in different location and distance from shore line. 200 meter line of survey data collected by using ABEM Terrameter LS associate 42 electrode, 42 clips, 2 main ERI cable with 5 meter interval clip. The data were processed by using Terrameter Toolbox and RES2DINV software.

Geochemistry test involved insitu and laboratory test. Physiochemical parameter were obtained which include salinity, EC, pH, TDS, turbidity. In situ test such as Salinity, TDS, TSS, Turbidity EC and pH. In addition, laboratory test also been done for Iron, Manganese, Copper, potassium and chloride.

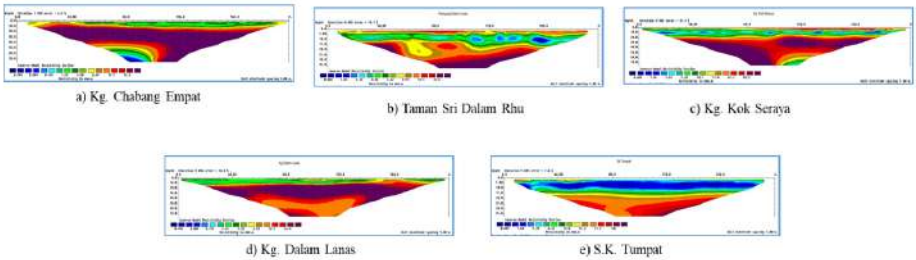


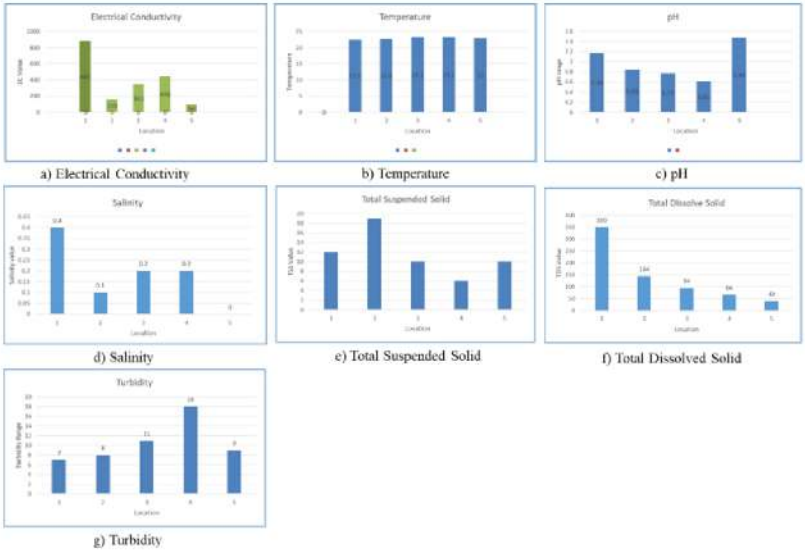
Figure 2. Result section of all locations. (a) Kg. Chabang Empat, (b) Taman Sri Dalam Rhu, (c) Kg. Kok Seraya, (d) Kg. Dalam Lanas, (e) S.K Tumpat

Table 1. Summary of result and interpretation of all survey line location

No.	Location	Summary result
a.	Kg. Chabang Empat	0.190-0.380 ohm is suspected as saline water. 1.52-24.3 ohm suspected fresh water associated with saline water. 1.52-24.3 ohm is suspected as clay/sand/alluvium sediment. Saline intrusion in 60-70m depth. Configuation: Pole – dipole.
b.	Taman Sri Dalam Rhu	All showing intrusion. 0.846-5.37 ohm is low saline intrusion with depth 0-15 m and associate with surface water. 8.53-21.5 ohm is clay material associate with saline intrusion from low to high intensity. Depth 15-35m alluvium sediment associate with salt water. No fresh water. Configuration: Schlumberger.
c.	Kg. Kok Seraya	0.668-20 ohm is suspected as salt water from low to high intrusion with depth 0 – 20 m. clay particle with salt water found in depth 20-30m with 5.34-21.4 ohm. 85.5 ohm show fresh groundwater and may associate with clay sediment/alluvium with depth 30 to 70m. Configuration: Pole – dipole.
d.	Kg. Dalam Lanas	0.195-20 ohm show saline intrusion. 1.56-24.9 ohm suspected as sand/clay with saline water. No fresh water until depth 70m. 20.70m is may be clay and alluvium with saline intrusion. Configuration: Pole – dipole.
e.	S.K. Tumpat	No saltwater intrusion of ground water aquifer. Resistivity value 0.801-103 ohm. 0,801-20 ohm within depth 0-20m is surface saline water. Clay exhibit in depth 20 -35m with 25.6-103 ohm. Fresh water with alluvium can be found in depth within 25 – 35m with 51.3-103 ohm. Configuration: Schlumberger.

Result of insitu test

Figure 3 show graph of in situ analysis of all open well in different location and Table 2 shows result of insitu test.



a) Electrical Conductivity b) Temperature c) pH

d) Salinity e) Total Suspended Solid f) Total Dissolved Solid

g) Turbidity

Figure 3. In situ test result of all location. (a) Electrical Conductivity, (b) Temperature, (c) pH, (d) Salinity, (e) Total Suspended Solid, (f) Total Dissolved Solid, (g) Turbidity

Table 2. Result of insitu parameter

No	Location	Electrical Conductivity (μScm^1) (750-2000)	Temperature (^0C)	pH (5.5-9.0)	Salinity (ppt) (0.15-1.0)	Total Suspended Solid (50) (mg/L)	Total Dissolved Solid (1500) (mg/L)	Turbidity (NTU) (50)
1.	Kg. Jubakar Pantai	887	22.5	7.18	0.4	12	350	7
2.	Pekan Tumpat	343	23.2	6.77	0.2	10	144	8
3.	Kg. Chabang Empat	446	23	6.61	0.2	6	94	11
4.	Kg. Kelong	159	22.8	6.84	0.1	19	66	18
5.	Kg. Kok Seraya	94	23	7.48	0.0	10	40	9

3.3 Result of trace elements

Figure 4 show distribution of trace element of open well in five different location and chemical concentration of few ions is given in table 3.

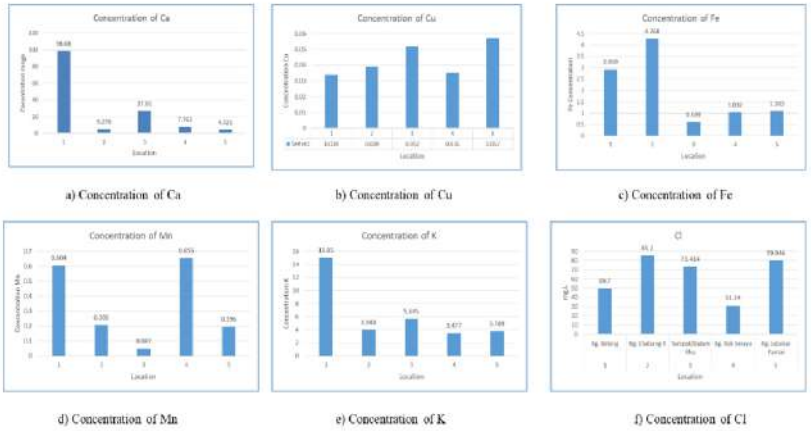


Figure 4. Distribution trace element result of all location. (a) Concentration of Ca, (b) Concentration of Cu, (c) Concentration of Fe, (d) Concentration of Mn, (e) Concentration of K, (f) Concentration of Cl

Table 3. Result of chemical concentration

No.	Location	Cu^{2+} (mg/L) (1.0)	K^{+} (mg/L) (30)	Mn^{2+} (mg/L) (0.2)	Ca^{2+} (mg/L) (200)	Fe^{2+} (mg/L) (1.0)	Cl^{-} (mg/L) (250)
1.	Kg. Jubakar Pantai	0.034	15.05	0.604	98.68	2.919	79.946
2.	Pekan Tumpat	0.039	3.983	0.205	5.276	4.268	73.414
3.	Kg. Chabang Empat	0.052	5.645	0.047	27.01	0.599	85.2
4.	Kg. Kelong	0.035	3.477	0.655	7.763	1.032	49.7
5.	Kg. Kok Seraya	0.057	3.798	0.196	4.521	1.103	31.24

Discussion

Generally, all the results from resistivity survey showing seawater intrusion. However, pole dipole configuration able to determine result of seawater intrusion into groundwater aquifer. Schlumberger configuration able to capture result of saline intrusion of surface water and first layer aquifer. Table 1 shows result of saltwater intrusion in 5 different location of survey line. In general resistivity value of sawater in alluvium is 0.2 ohm until 20 ohm and fresh water is about 50 until 150 ohm. Fresh water can easily be found in second aquifer with depth 30 meter and below. Second layer of aquifer contain depth of 20 meter and below [3]. The result shows seawater intrusion into all groundwater aquifer in first aquifer of Kg. Dalam Lanas and Kg. Chabang Empat showing high sewater invasion with resistivity value is more than 0.190 and 0.195 ohm. However, distance of Kg. Chabang Empat from shore line quite far than Kg. Dalam Lanas indicate the area is intruded by seawater massively. Depth of intrusion is 60 -70 meter in case of. Kg. Kok Seraya which shows low resistivity value which is about 0.8 ohm. However, seawater intrusion can be identified in all locations in first layer of aquifer associate with gravel, sand and clay sediment.

In addition, the purpose of groundwater quality analysis were also performed in the locations which was close to resistivity survey line and this anaysis supported resistivity result. Few insitu parameters analysed such as EC, pH, salinity, TDS and turbidity. Electrical conductivity values shows higher in. Kg. Jubakar Pantai which is 887 micro siemen per centimetre. This is because the distance of the open well from shore line is to close and also similar results shows in S.K Tumpat. Kg. Chabang Empat and Bandar Tumpat. The pH value varies from 7.48 to 6.61 which basic to acidic. Human activities such as agriculture affect pH value along with precipitation and infiltration during raining season when aquifer become recharge. However, all the values still in safe range and suitable to use. Another important parameter is salinity that measure how much groundwater affect by seawater. Salinity in Kg. Jubakar Pantai showing highest value which is 0.4 ppt among all location of open wells as the location is close to shore line with depth of open well around 3 meter. Bandar Tumpat and Kg Chabang Empat showing least saltwater intrusion as the location quite far from shore line. However, resistivity survey from Kg Chabang Empat showing high saline intrusion in depth of 60 until 70 meter which is second and third layer aquifer. The value of TDS show high in Kg. Jubakar which is 350 mg/L and Kg. Kok Seraya has the lowest value which is 40 mg/L. In addition turbidity also measures which shows high in Kg. Kelong around 18 NTU. This high turbidity values probably mostly of the wells are always open and not properly covered.

Some other parameter also analysed such as Cu, Fe, Mn, and Cl. The concentration of copper in all locations within permissible limit. Iron concentration in all location is too high and exceed permissible limit which is 1 mg/L. Bandar Tumpat shows highest value which is 4.268 mg/L followed by Kg Jubakar that is 2.919 mg/L. Others location is 1.0 mg/L. Based on iron concentrations the water from these wells not suitable for drink purpose. Manganese concentrations also shows high which is 0.65 mg/L in few locations and this concentration is beyond permissible limit that is 0.2 mg/L. The concentration of chloride in Kg Jubakar and Kg. Dalam Rhu shows 85.2 and 79.95 mg/L respectively. These high values probably the location is near to shore line.

Conclusion

The authors are gratefully acknowledged to all staff of Faculty of Earth Science, University Malaysia Kelantan for providing the facilities to carry out this research.

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GROUNDWATER QUALITY OF HARD ROCK: A CASE STUDY FROM BATU MELINTANG AREA JELI, MALAYSIA

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Abstract

Groundwater is vital to life, and a nominal supply of clean-safe drinking water is needed for the sustenance of life. Batu Melintang being an important sub district in Jeli, a broad scale survey in Batu Melintang area was conducted to assess the groundwater quality. Most of the wells found in this area were located nearby Gunung Reng which is a limestone cave. Twelve samples were collected covering an area of about 25km^2. Physicochemical parameters of groundwater were analysed to determine the quality of the water and were classified according to the drinking water quality standards of WHO and MHO. Laboratories assessments were made to determine the concentration of the ions present in the drinking water. All the wells show that the water is fit to drink even though some of the values have high reading compared to the others except for the well location of sample 7 in Kg. Kalai. The concentration of Calcium, Potassium and hardness exhibit higher values than the water quality standards. These high Calcium and Hardness values can be well attributed to the geogenic processes involving weathering of the limestone rocks in the area. However, Potassium can be contributed by agricultural activities in addition to the rock weathering. Overall, the current status of groundwater is safe and satisfactory except for well 7 which needs some proper treatment before using it for drinking.

Keywords: Groundwater, Quality, Hardrock, Jeli, Malaysia.

Introduction

Northern Kelantan is presently at the forefront of groundwater abstraction for potable water supply usage, but outside northern region are yet to be developed and exploited due to the presence of hard rock (igneous, metamorphic and meta-sediments) and mainly depend on sur-face water and only few places extracting groundwater from weathered zone. The study area is Batu Melintang is a sub-district of Gunung Reng, along the East-West Expressway in Jeli district in western Kelantan. The area partly covered by Batu Melintang and the area of Gunung Reng (Fig 1). Geologically the area is mainly composed of metamorphosed limestone (marble) sitting on the intrusive body (granitic rocks) and surrounded by quaternary alluvial deposits (Fig 2). Mostly groundwater samples collected from domestic wells in the karst re-gion where water quality may be unsafe due the karstic nature. Keep in this intention the pre-sent research are carried out to analyze the suitability of groundwater for different uses.

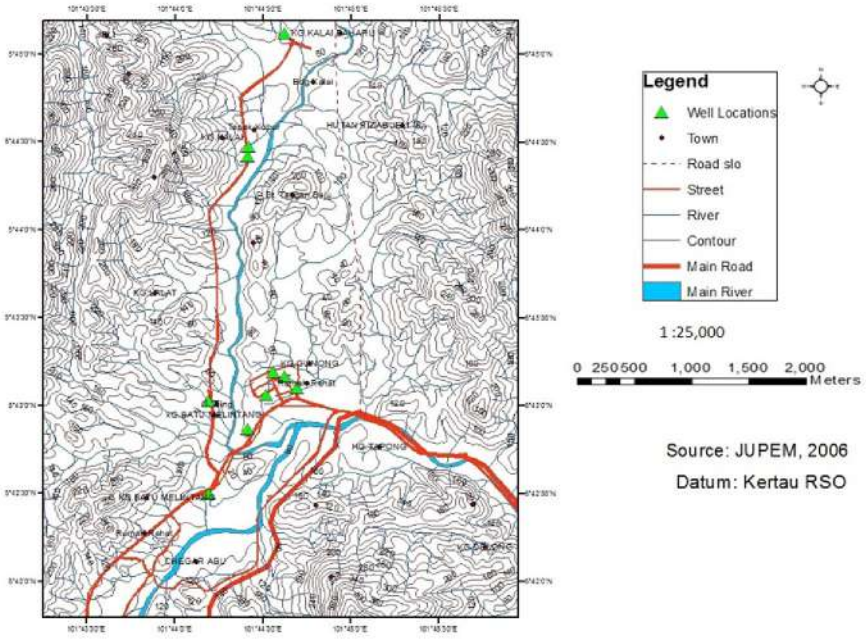


Fig 1. Location map of the study area.

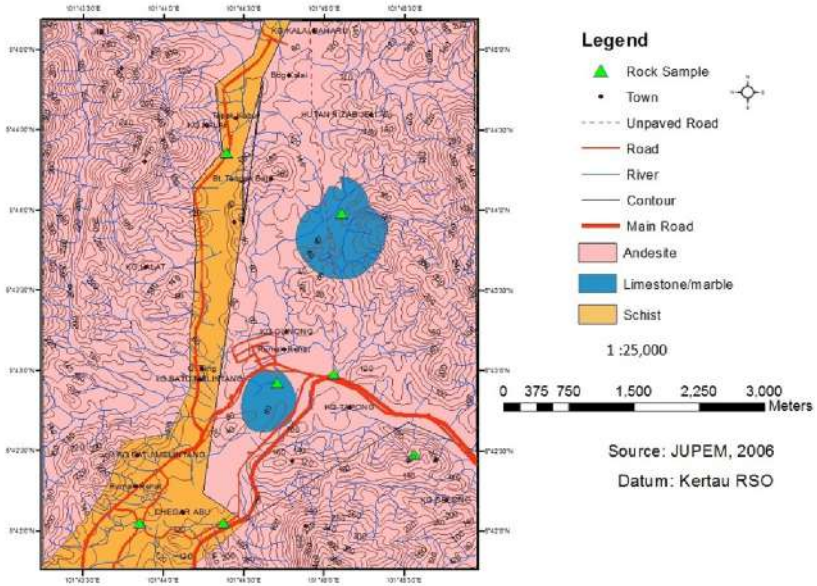


Fig 2. Lithology map of the study area.

Materials and Methods

A total of 11 sampling sites were selected throughout the study area. Sampling sites chosen in areas where shallow groundwater is used for household consumption and water extracted through a pump engine.

In situ parameters such as total dissolved solid (TDS), temperature (ºC), electrical conduc-tivity (EC), turbidity and pH were measured on site using a potable water digit analysis kit. Major cations including calcium (Ca+), magnesium (Mg2+), potassium (K+), sodium (Na+) are analysed using Atomic Absorption Spectroscopy (AAS). The major anions including bi-carbonate (HCO3-), chloride (Cl-), sulphate (SO42-) and other anions including nitrate (NO3-) and fluoride (F-) were analysed using titration method, gravimetric method and colorimetric method respectively.

Results

Results of chemical analysis and comparison of results are presented in table 1, 2, and Fig 3. 4 are given below.

Table 1. Results for Physical parameters of groundwater samples.

S.No	pH	Turbidity	Temperature (C°)	EC (µS/cm)	TDS (mg/L)	Salinity	DO (%),	Hardness (mg/L)
1	5.62	0.15	22.20	67	40.96	0.03	27.6	15.43
2	5.85	0.56	21.92	43	35.2	0.02	26.5	11.32
3	7.00	0.33	21.56	350	105.73	0.17	28.8	114.75
4	6.22	0.41	21.36	217	81.26	0.10	35.4	29.22
5	6.43	1.20	21.50	171	74.58	0.12	36.0	59.76
6	7.10	0.32	21.74	277	112.75	0.14	30.6	181.37
7	7.10	4.54	21.83	196	266.44	0.09	36.7	567.68
8	6.69	2.42	21.81	203	107.87	0.10	34.1	83.25
9	6.27	16.5	21.46	171	68.5	0.08	40.2	83.60
10	6.11	3.74	21.17	23	49.61	0.01	27.0	6.38
11	7.10	2.25	21.42	47	73.68	0.02	32.8	16.58

Table 2. Results of chemical analysis

S.No	Na	K	Ca	Mg	Cl	F	HCO_3	NO_3	SO4
1	3.97	4.54	5.09	0.66	11.36	0.11	04.14	7.8	3.29
2	6.61	2.42	2.64	1.15	05.68	0.15	05.94	1.7	8.97
3	2.47	1.76	43.90	1.22	11.36	0.10	39.60	0.3	5.02
4	27.34	2.33	10.67	0.62	31.24	0.17	05.40	0.2	3.29
5	7.80	1.81	22.61	0.79	17.04	0.06	18.00	0.3	6.17
6	2.47	3.01	69.40	1.92	09.94	0.10	21.60	1.1	3.21
7	1.28	23.24	224.3	1.69	07.10	0.15	05.40	0.4	2.88
8	0.53	1.27	31.30	1.22	09.94	0.13	57.60	0.7	5.18
9	2.57	1.13	25.73	4.70	05.68	0.13	25.20	0.4	2.96
10	7.32	0.31	0.78	1.08	07.10	0.15	28.80	0.2	3.87
11	3.54	0.49	4.40	1.36	04.26	0.12	57.60	0.1	1.81

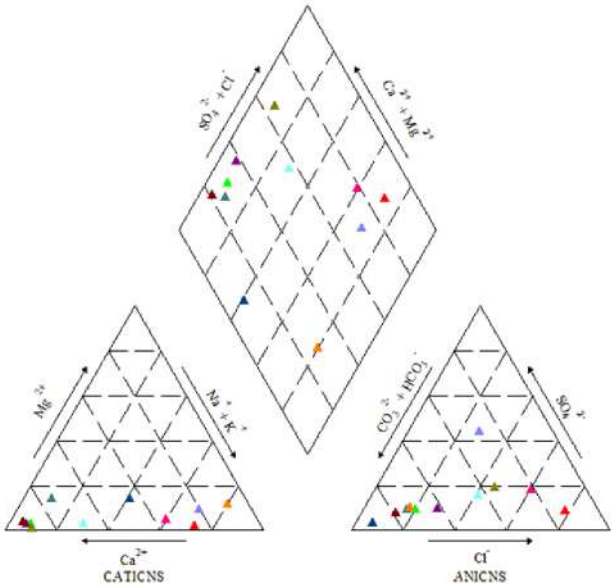


Fig 3. Piper trilinear diagram

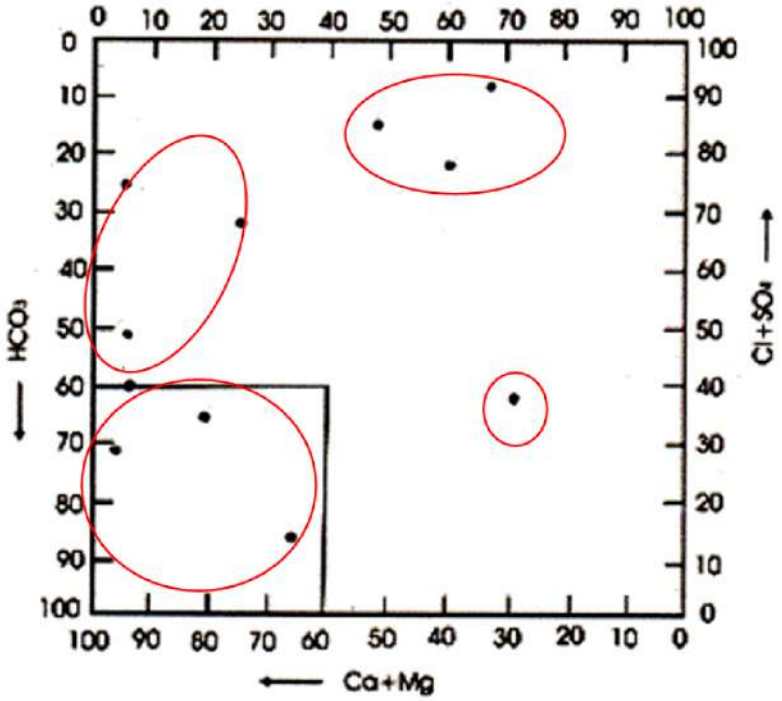


Fig 4. Ludwig – Langelier diagram (LL diagram)

Discussion

In study area hardness value varies between 6.38mg/l to 567.68 mg/l. Only sample 7 shows higher concentration which is more than the desirable limit of drinking purposes of 300 mg/l [1] while others samples fall under soft category of hardness. Insitu parameters such as Total dissolved solids (TDS), Electrical conductivity, pH, salinity, dissolved oxygen of all 11 sam-ples considered to be good as it all lies within the range of fresh water based on WHO while turbidity shows high only in sample 9 and it might be caused by corrosion of the pipe.

Sodium and magnesium shows under permissible limit while calcium and potassium show-ing higher concentrations values in one sample 7 and the high values of calcium probably due to dissolution of calcium in limestone rock. The location of this well is nearby limestone cave. In addition, the higher concentrations of potassium suggest the possibilities of fertilizer's us-age in the study area.

The concentrations of bicarbonate chloride, sulphate, nitrate and fluoride in all groundwater samples shows within the permissible limit range of [1] and [2] and all samples are suitable for drinking purposes based on the above anions.

Classification of groundwater in the study are is classified on the basis of piper trilinear di-agram and LL diagram (Fig 3, 4). Using the both Piper Trilinear and Ludwig-Langelier dia-gram the groundwater are classified into four types namely Na-HCO3-Cl, Na-Ca-HCO3-Cl, Ca-Na-HCO3-Cl and Ca-Mg-HCO3-Cl.

Conclusions

All the samples are suitable for drinking purposes except only in sample number 7 and 9 shows higher concentration of hardness, calcium and potassium which is more than the per-missible limit of drinking water quality of WHO, 2011 and this high concentration probably due to dissolution of lime stone and excessive use of fertilizers in the study area. As a rec-ommendation the water from the particular wells must be treated before consuming the water as well as keep regular quality monitoring for the benefits of the people in the area.

Acknowledgements

The authors are gratefully acknowledged to all staff of Faculty of Earth Science, University Malaysia Kelantan for providing the facilities to carry out this research.

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EVALUATION OF SEAWATER INTRUSION IN SHALLOW AQUIFER OF KEMUMIN, KOTA BHARU USING INTEGRATED GEOPHYSICAL & GEOCHEMICAL METHODS

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Abstract

This study focuses on evaluation of seawater intrusion in shallow aquifers of Kemumin, Kota Bharu that is located near the shoreline. Seawater intrusion in shallow aquifers can pose serious issue as it can cause contamination of groundwater. Therefore, integrated approach is applied using Electrical Resistivity Imaging (ERI) method which include using ABEM Terrameter LS of 200 meter line with 41 electrodes and 5 meter spacing to produce a 2D imaging of the subsurface using RES2DINV software. The aforementioned method was integrated with in situ geochemical analysis to gather data with the parameters such as pH, temperature, salinity, turbidity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Electrical Conductivity (EC) and laboratory analysis using Atomic Absorption Spectroscopy (AAS) and titration analysis at five well locations. A total of three resistivity survey lines were conducted by applying Wenner, Schlumberger and Pole-dipole array. Based on resistivity profile, only two locations of survey line showing seawater intrusion at approximately 5 to 20 meter depth. Based on salinity results, the samples collected near the shoreline (AT1, AT3, AT7 and AT8) show high salinity values but based on other chemical parameters all the groundwater samples are safe to use and within the permissible limit of the National Guideline of Raw Water Quality Standards by Ministry of Health, Malaysia.

Keywords: Seawater Intrusion, Shallow Aquifer, Kelantan.

Introduction

Seawater intrusion is a type of groundwater contamination especially near the shorelines area or coastal aquifers by interfering its chemical equilibrium and physical properties. The essential hindering impacts of seawater intrusion are decrease in the accessible freshwater supply volume and tainting of production wells, whereby under 1% of seawater (approximately 250 mg/L chloride according to world health organization [1] which renders freshwater unsuitable for drinking. Currently, total groundwater consumption is 134 MLD, which represents about 41% of total water production in the water treatment plants of AKSB. The 2.5 percent increase per year suggests that demand for potable groundwater would be around 210 MLD in 2020, rising to 270 MLD in 2030 (Rainhill Consulting Sdn. Bhd., 2011). Due to this, it is imperative to monitor the seawater intrusion into freshwater aquifer as it causes a decline in the quality of the groundwater according to appropriate standard usage

Materials and methods

This preliminary study were done around in Kemumin, parts Kota Bharu, Kelantan (Fig 1) and focus lectrical resistivity and chemical parameter. The electrical resistivity imaging was conducted using ABEM Terrameter SAS 4000 where 41 electrode were arranged in a straight line and connected to a multicore cable. The field survey was conducted along three profiles where the length of each profiles is 200 m with an electrode spacing of 5 meter. The data then were processed using RES2DINV software to obtain two-dimensional (2D) resistivity profiles for interpretation. In addition, in-situ hydrochemical analysis were also performed in order to monitor a few physical parameters such as EC, TDS, TSS, temperature, pH, turbidity, salinity as well as laboratory analysis using Atomic Absorption Spectroscopy (AAS). data and also in situ chemical parameters data collected to support the results obtained by the ABEM Terrameter LS. This is all part included in the integration of methods used to complete these investigations.

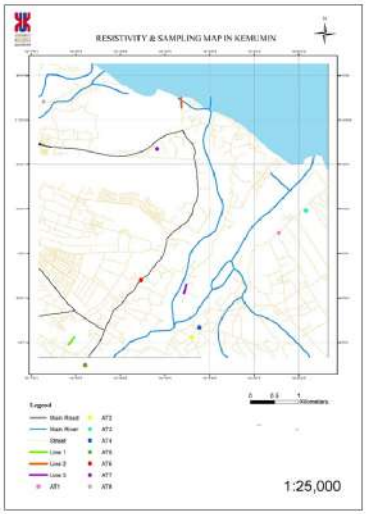


Figure 1. Sampling Location map

Results

Resistivity Surveys

Three survey lines were conducted to represent seawater intrusion. All lines are given below.

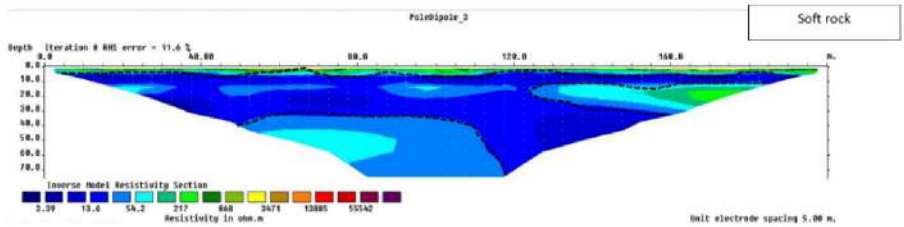


Figure 2. Resistivity survey line 1

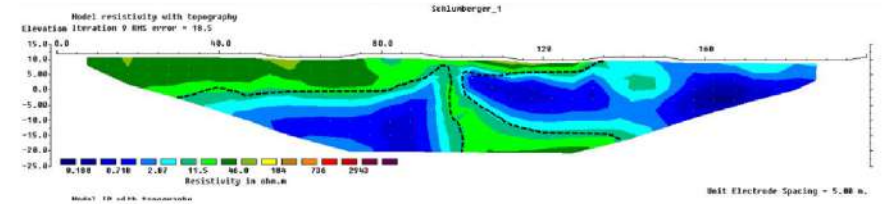


Figure 3. Resistivity survey line 2

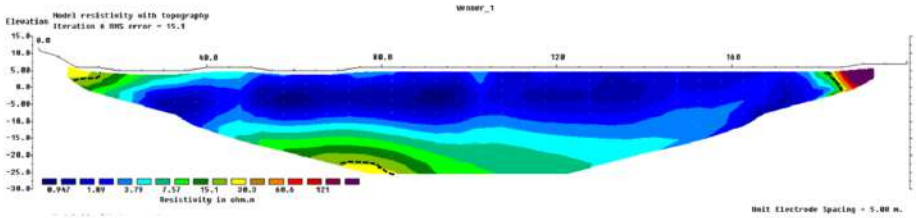


Figure 4. Resistivity survey line 3

Figure 2 shows minimum resistivity value in this survey line is 3.39 Ωm and the highest value is 55,542 Ωm with depth of about 70 meters. Based on the resistivity value shown, there is saline water presence as the minimum value of resistivity below than 20 Ωm. It means that groundwater already started to turn saline even though the area is far from the shoreline and this intrusion probably due to high amount of groundwater extraction.

Minimum resistivity value in Figure 3 shows in survey line 2 is 0.18 Ωm and the highest value is 2,943 Ωm with depth of about 20 meters. Based on result in Figure 2, there is saline water presence as the minimum value of resistivity was below than 20 Ωm. This value indicate the range of saline water intrusion for 0.18 Ωm to less than 20 Ωm. Based on this value, the aquifers already contaminated.

Minimum resistivity value in survey line 4 is 0.947 Ωm and the highest value is 121 Ωm with depth of about 25 meters. Based on the Figure 3, there is small value from 0.947 Ωm shows of saline water presence as the minimum value of resistivity was below than 20 Ωm.

In Situ Chemical Parameters

All water samples analysis results given in Table 1, 2 and 3.

Sample Name	Type of water sample	Latitude, N	Longitude, E	Elevation above sea level	Distance from shoreline
AT1	Boring well	6.153852	102.3379	5 m	1.9 km
AT2	Boring well	6.13429	102.321725	9.7 m	4.24 km
AT3	Boring well	6.158035	102.343035	14 m	0.9 km
AT4	Dug well	6.136083	102.323089	5.5 m	4.05 km
AT5	Boring well	6.129023	102.301557	9.9 m	5.90 km
AT6	Dug well	6.145016	102.312147	7.5 m	3.85 km
AT7	Dug well	6.169551	102.315189	6.6 m	1.28 km
AT8	Boring well	6.178448	102.293969	6.0 m	1.15 km

Table 2. In situ physical parameters of collected water sample in study area

Sample	pH range	Temperature, °C	TDS, mg/L	TSS, mg/L	Turbidity	Salinity, ppt	EC, µS/cm
AT1	6.75	20.4	453	169	5.67	6.2	99
AT2	7.2	19.7	514	40	4.87	7.2	112
AT3	6.52	30.57	103	179	0.47	8.1	159.8
AT4	5.81	31.24	102	122	9.9	0.1	156.9
AT5	5.93	33.61	142	135	8.79	0.1	219.6
AT6	6.19	30.33	321	20	9.99	0.2	494.0
AT7	4.2	31.66	951	178	0.47	5.8	146.2
AT8	6.54	31.71	156	67	1.86	5.3	241.1

Table 3. Chemical concentrations of groundwater samples in mg/l

Sample	Cu^+	Fe^+	K	Mn^+	Na	Cl
AT1	0.031	1.384	3.199	0.040	5.360	47.85
AT2	0.048	0.718	22.93	0.129	50.26	42.6
AT3	0.042	2.650	41.33	0.071	777.2	44.02
AT7	0.052	2.168	3.143	0.378	43.74	36.50
AT8	0.027	0.267	5.650	0.341	6.889	49.27

Discussion

Based on the in situ parameters, a few deductions can be made to justify the resistivity data. Total Dissolved Solids (TDS) of water samples around Kemumin, Kota Bharu varied from 453 mg/L to 514 mg/L with the average value of 362.25 mg/L and all samples within permissible limit of MOH. Among all the collected water samples, AT7 shows the highest value of 514 mg/L compared to other water samples. The amount of TDS in these samples varied may be affected by types of minerals that make up the aquifers, the length of time which water is in contact with the minerals and chemical state of the groundwater. Electrical conductivity (EC) in the study area recorded from 494 µS/cm to 99 µS/cm. AT6 shows the highest value which is 494 µS/cm. The salinity values ranges between 0.1 to 8.1 ppt. AT3 recorded the highest value of salinity due to its very close distance to the ocean while AT4, AT5 and AT6 recorded the lowest value of salinity which are still within the permissible limit according to MOH.

Concentrations of iron in study area ranged from 2.65 mg/L to 0.267 mg/L. The average of the iron ions concentration was 1.437 mg/L. Based on Table 3, only samples number AT2 and AT8 showed iron below the permissible limit compared to other samples which exceeds more than 1.0 mg/L. High concentration of Fe probably due to presence of old pipes used for plumbing that contaminates the groundwater.

Manganese ions concentrations in study area ranged from 0.04 mg/L to 0.378 mg/L with the mean value of 0.192 mg/L. Sample AT7 and AT8 show high manganese ion concentration which is more than permissible limit and it is not safe for drinking purpose. The high concentration of manganese ion are probably due to contaminants that seeps into the ground. The range of sodium ions concentration of water samples ranges from 5.36 mg/L to 777.2 mg/L with overall average concentration of 176.69 mg/L of sodium ions. As shown above, AT3 has the highest value of sodium ions which is 777.2 mg/L which is more than permissible limit that clearly shown seawater intrusion. This result also supported by other parameters such as salinity that also show high value in the same samples. Presence of chloride ions are the one of the best indicators to detect seawater intrusion as the main component of salt water is NaCl. Based on Table 3, all the samples are still within the permissible limit which does not exceed 250 mg/L and still safe for consumption. Based on resistivity data, the result shows there are indicators of seawater intrusion supported by geochemical result of groundwater samples.

Conclusion

As conclusion, a few groundwater samples are not safe and not suitable for usage of all purposes in daily life as the data collected was compared to the Guidelines of Raw Water Quality Standard from the Ministry of Health of Malaysia. Based on the result obtained from Electrical Resistivity Imaging (ERI) survey, there is quite distinct border in which the seawater and freshwater interface occurred at 2 to 3 kilometers from the shoreline. This statement can be justified by the resistivity profile shown in Survey Line 2 and resistivity survey line 3 show a small amount salinity presence inside its shallow aquifer which can be supported by data collected from nearest groundwater well (sample AT4 and sample AT6).

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THE IMPORTANCE OF NATURAL COAGULANT AND ITS COAGULATION MECHANISM IN WATER TREATMENT

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Abstract

Coagulation-flocculation is the key process of water treatment in water turbidity removal. Usage of conventional inorganic coagulant such as aluminum sulphate and ferric chloride are required for the process. However, usage of inorganic coagulants has raised awareness of researchers due to the threat possess on human health and environment. Therefore, studies in natural coagulant has become highly focused field of study in providing clean water for the community. Natural coagulants are widely available and non-toxic that can be obtain from animal, fungi, bacteria, and plant. Recent years, plant-based coagulant such as the Moringa Oleifera, Lentil (Lens Culinaris), Watermelon (Citrullus Lanatus) seeds and Pinecone extract has also shown positive results in water turbidity removal for water treatment. Plant-based coagulants acts as a destabilizer to neutralize the negatively charged particles in the water to form microflocs and flocs that will then be dispose as sludge for water turbidity removal. Natural coagulants were also characterized in terms of functional group through Fourier Transform Infrared Spectroscopy (FTIR) Spectroscopy Analysis, surface charge through Zeta Potential analysis and surface morphology through Field Emission Scanning Electron Microscope (FESEM) analysis for better understanding on its mechanism.

Keywords: Natural Coagulant, Plant-based Coagulant, Coagulation-flocculation, Coagulation Mechanism,Coagulant Characterization.

Introduction

Water is a necessity and an essential need to human being as well as all living forms on earth. However, fresh water in the globe is relatively low which is equal or less than 2% of the amount of total water body on earth (Al-aubadi, Hisham, & Khaleel, 2017). Therefore, concern of having fresh and clean water is crucial throughout the whole world.

On the other hand, water sources from lakes and rivers are also polluted by suspended particles due to the soil erosion, discharge of human waste, industrial effluents and run-off from agricultural lands (Saritha, Karnena, & Dwarapureddi, 2019). Therefore, measures to produce clean water were required to be taken into consideration prior to distributing the waters.

To provide clean and safe water that are pathogenic free, harmless, tasteless, odourless and colourless (Yongabi, 2010) to the community, proper water treatment is required. There are several practices used in the industry for wastewater treatment which includes, electrochemical treatment, coagulation - flocculation, ion exchange, adsorption and membrane filtration. Table of comparison for available treatment practices are listed as below (Ahmed & Ahmaruzzaman, 2016):

Table 1: Comparison of available treatment practices for removal in wastewater

Practices	Advantages	Disadvantages
Electrochemical Treatment	Rapid process but only for specific metal ions	Energy cost is high and produce of by - products
Coagulation - Flocculation	Cost efficient	Volume of sludge production is high
Ion Exchange	Efficient in removing wide range of heavy metal	Regeneration and disposal problems of absorbent material
Adsorption	Flexible and simple design, easy operation and not sensitive to toxic pollutant	Requirement of adsorbent regeneration
Membrane Filtration	Efficient in heavy metal removal	Produce sludge and high cost

Coagulation-flocculation process is one of the key practices for water treatment. The process is a simple yet cost-effective method in the industry for providing clean drinking water. Coagulation-flocculation is a common process which includes in a pre- or post-treatment procedure in the industry for both water treatment as well as wastewater treatment. The process aims to remove the turbidity of water as well as separates the total suspended solids from the water (Ramavandi, 2014). Removal of suspended solids is critical due to the water quality deterioration caused by various organic matters which are toxic.

Coagulant

In coagulation-flocculation process, coagulant acts as substance to clot and curdle the particles in the water to form flocs for sedimentation. Conventional inorganic coagulant that are widely used in the industry are aluminium sulphate (alum) and iron (III) chloride. The conventional inorganic coagulants have shown positive coagulation-flocculation results and are widely available elements on earth.

However, recent studies and research have indicated that the usage of conventional inorganic coagulant potentially possesses threat to both human health and the environment. Various threat of conventional inorganic coagulant in water treatment are listed as below:

- Usage of alum as coagulant has been a contributing factor of Alzheimer's Disease in human health (D'Haese et al., 2019).
- Aluminium has been categorised as scheduled waste where alum generated sludge are also required to comply for special treatment and proper disposal which leads to a higher cost during sludge disposal [SW204] ("Environmental Quality (Scheduled Wastes) Regulations," 2005).
- Production of inorganic coagulant, Iron (III) Chloride are the contributing factor to ozone depletion due to the emission of greenhouse gas during production (Vince, Aoustin, Bréant, & Marechal, 2008).

Hence, replacement of conventional coagulant has raised interest and attention of researchers to explore into new alternatives to benefit both human health as well as the environment for the better of the globe.

Natural Coagulant

Natural coagulant as a replacement alternative has become a study of interest for researchers as they are non-toxic, renewable, degradable, and widely available. Various studies of natural coagulant have been conducted by using the sources from various bacteria, fungi, animals, and plants.

Recent studies, positive results have been shown in the plant-based coagulant as workable replacement to the current conventional chemical or inorganic coagulant in reducing water turbidity for both water and wastewater treatment. Plant-based coagulant are usually extracted from the seeds (Ernest, Onyeka, David, & Blessing, 2017) or the leaves (Benalia, Derbal, Panico, & Pirozzi, 2018) of the plant through various extraction method such as solvent extraction and precipitation (Zaid & Ghazali, 2019) as well as dry and ground process (de Jesus, Victor Cruz, Adair Pacífico, & Santos Silva, 2014). Various natural plant-based coagulant has been conducted in recent studies and have been summarized in Table 2.

Table 2. Plant-based coagulant in water treatment recent studies

Coagulant	Part Extracted	Test Sample	Optimum Results		Reference
Moringa Oleifera	Seed	Ground water	Turbidity Removal	12.4NTU → 3.1NTU	(M., G., & P.D., 2012)
Lentil (*Lens Culinaris)*	Seed	Turbid Water (Kaolin)	Turbidity Removal	98.87%	(Chua, Malek, Chong, Sujarwo, & Ho, 2019)
Watermelon (*Citrullus Lanatus)*	Seed	River Water	Turbidity Removal	67.70NUT → 9.42NTU	(Ernest et al., 2017)
Pinecone	Fruit	Turbid Water (Kaolin	Turbidity Removal	82%	(Hussain, Ghouri, & Ahmad, 2019)

Physio-chemical Characterization of Natural Coagulant

The binding mechanism is determined by various physio-chemical laboratory analysis for characterization of the natural coagulant. The natural coagulants will be characterized through laboratory test of Fourier Transform Infrared Spectroscopy (FTIR) Spectroscopy Analysis, Zeta Potential analysis, and Field Emission Scanning Electron Microscope (FESEM) analysis as summarized in Table 3.

Table 3. Characterisation of physio-chemical properties

Analytical test	Purpose of test	Reference
Fourier Transform Infrared Spectroscopy (FTIR)	To detect the functional groups on the natural coagulant	(Meng Xu, Pejman Hadi, Guohua Chen, & Gordon McKay, 2014; M. Xu, P. Hadi, G. Chen, & G. McKay, 2014)
Zeta Potential test	To measure the surface charge of particles suspended in solvent.	(Meraz et al., 2016)
Field Emission Scanning Electron Microscope test (FE-SEM)	To observe the morphology, shape and size distribution of nanoparticles.	(Darroudi, Bagherpour, Hosseini, & Ebrahimi, 2016)

Coagulation Mechanism

There are several coagulation mechanisms for water treatment coagulation-flocculation process which includes, charge neutralization, polymer bridging, sweep coagulation, double layer compression and electrostatic patch. Based on studies, charge neutralization and polymer bridging are considered as most common and possible coagulation mechanism for plant-based coagulant (Kristianto, 2017).

Charge Neutralization

Charge neutralization mechanism occurs when opposite charge coagulant polymer is absorbed on to the charge of suspended particles in the water, thus neutralizing the particle charges. According to researches, suspended particles in water are commonly negatively charge whereas coagulant polymers are positively charge (Lee, Robinson, & Chong, 2014). Therefore, different charges in the water will stabilizes the suspended particles in water by reaching a zeta potential of near to zero which allows the Van der Waals force of suspended particles to coagulate among each other to form flocs.

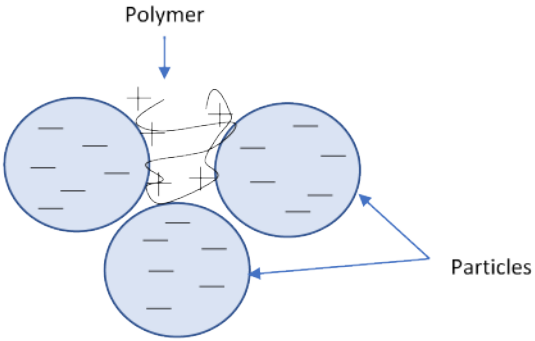


Figure 1. Charge neutralisation between polymer

Polymer Bridging

Polymer bridging occurs when long chain polymers adsorbed suspended particles due to the high molecular weight and low charge density of polymer (Lee et al., 2014). It has allowed the possibility of polymer to attach and interact with particles which causes bridging between them. Adsorption energy of the particle size significantly influences the bridging conformation and bond strength between particles (Kamibayashi, Ogura, & Otsubo, 2008). Therefore, one of the controlling factors of bridging mechanism is the particle size and particle diameter of the suspended solids. Hence, large particles require more polymer segment whereas small particles require small polymer chain.

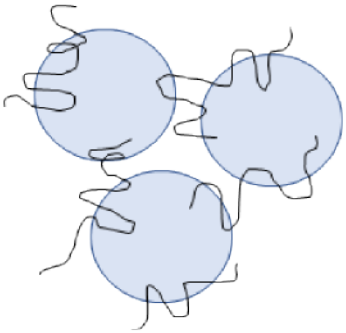


Figure 2. Polymer bridging between particle schematic view

Conclusions

Natural coagulant for coagulation-flocculation in water treatment is highly beneficial for both human health and the environment. Hence, implementation of natural coagulant should be considered as a replacement of conventional inorganic coagulant. Extracted plant-based coagulants are also excellent replacement as they have shown positive efficiency within them. Lastly, various studies and research of natural coagulant in water treatment industry still have its room of exploration depending on types of materials used as coagulant.

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ASSESSMENT THE IMPACT OF SEA LEVEL RISE ON COASTAL COMMUNITY IN KUANTAN, PAHANG

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Abstract

The coastline is one of the important components of global sustainability. This area has a variety of functions, including high ecosystem productivi-ty, the concentration of population, with good transport infrastructure, industrial and tourism centre. All of these functions have made the coastal area as an important source of income. Climate change is causing global warming is increasing the impact of sea level rise in coastal areas, which resulted in the overflow problem in coastal areas, coastal erosion and the destruction of ecosystems. This study was conducted to assess the impact of sea level rise on coastal vulnerability that includes the coastal area from Cherating to Pekan in terms of physical and economic aspects. The combination of geospatial technique, hydrodynamic modeling and interview technique and field observations involving 36 villages used to integrate data in order to produce results more comprehen-sive. The study found that the inundation scenarios for the forecast in 2020, 2040, 2060, 2080 and 2100 show a significant impact on the de-velopment area. Three regions, namely Tanjung Cherating to Sungai Cherating, Tanjung Payang to Sungai Balok, and Cheruk Paloh to Kuala Pahang categorized suffering from the effects of rising sea levels. In ad-dition, 80% of the 36 villages that investigation run the main activity is agriculture, small enterprises and tourism. Most of the beaches in the study area as Cherating, Teluk Chempedak, Pantai Sepat and Tanjung Lumpur are an example of the best beaches that attract people for leisure and tourism. Therefore, the findings help produce integrated adaptation strategies and measures to stakeholders in order to achieve sustainable development in coastal areas.

Keywords: Sea Level Rise, Coastline, Cosatal Community, Geospatial, Inundation, Hydrodynamic.

Introduction

The beach is always a danger of the exposed area and the situation is worsened by the phenomenon of climate change is happening (IPCC, 2012; Nicholls et al., 2008). Globally, climate change threatens coastal areas and coastal communities. Sea level rise is expected to produce adverse effects such as subsidence of the sea coast, flooding and coastal erosion in coastal and low-lying areas (IPCC, 2014). The impact is expected to affect the socio-economic activities of coastal communi-ties (Nicholls et al., 2008). According to the Small and Nicholls (2003), approximately a quarter of the world's population is within 100 km of the coast, and this number is expected to increase in 2030 and, for sure, this population is vulnerable to the effects of climate change.

Similar to the global scenario, climate change will also affect coastal areas in Malaysia. It has been shown that the coastal communities in the face of rising temperatures (Wei et al., 2005; Kwan et al., 2011); sea level rise (Ami Hassan, (2009), (2012); Awang and Hamid, 2013; Luu et al., 2015; Sarkar et al., 2014); unstable rain patterns and thunder-storms (Wan Azli, 2010); strong wind and waves (Kajikawa et al., 2012) and the northeast monsoon unstable (Wan Azli, 2010; Kajikawa et al., 2012; Omar et al., 2013; Suhaila et al., 2010).

Such changes, according to some local scholars such a big impact on public coastal dependent on resources original, including the sea, beaches and mangroves for their fisheries, tourism, small and medium enterprises (SMEs) and social activities (Muhammad et al., 2012; Shaffril et al., 2013). Detection for the impact of physical and economic aspects can be performed using numerical hydrodynamics modeling. The results capable of determining the risk of the affected areas such as floods or drowning. It can be used as a preventive measure and adapta-tion by coastal communities facing the effects of climate

Material and Methods

The study area has involved the coastline in Pahang (Cherating to Pek-an), which covers 87 km along the coastline. Simulation modeling nu-merically using software MIKE21 was performed by the projection Sea Level Rise (SLR) in the waters of the Pahang coast for 2020 (0.036m), 2040 (0.086m), 2060 (0.153m), 2080 (0.234m) and 2100 (0.326m). The collection of marine data such as tidal level, flow direction, flow veloci-ty and bathymetry done in May 2017. The impact assessment for SLR from physical and socio-economic aspects are divided by 18 manage-ment unit (MU) starting from Cherating to Pekan within buffer zone 1-km from the coastline. Furthermore, the data collection was done using face to face interviews and observations conducted on March 9, 2017 to March 13, 2017 involving 36 villages. The total number of communi-ties involved were 498 peoples from coastal communities in Pahang.

Results and Discussion

The impacts of sea level rise in terms of physical elements

Based on Table 1, the area of Cherok Paloh - Kuala Pahang (MU18) indicates the area most affected by severe inundation of 64.14 to 292.38 hectares in 2020 to 2100. Area of Jeti Gebeng - Pelabuhan Kuantan (MU4) and Pelabuhan Kuantan - Tjg. Payang (MU5) showed no effect of inundation occurred in line with the physical condition of the area that has had protective structures along the port area.

Table 1. Area of inundations based on the prediction of Sea Level Rise in Cherating to Pekan in 2020 until 2100.

MU	Location	Year 2020 (ha)	Year 2040 (ha)	Year 2060 (ha)	Year 2080 (ha)	Year 2100 (ha)
1	Tjg. Cherating - Sg. Cherating	17.35	20.00	26.07	31.97	32.41
2	Sg. Cherating - Sg. Ular	7.21	44.60	64.66	76.69	77.35
3	Sg. Ular - Jeti Gebeng	24.86	46.17	56.06	58.94	59.31
4	Jeti Gebeng - Pelab. Kuantan	0	0	0	0	0
5	Pelab. Kuantan -Tjg. Payang	0	0	0	0	0
6	Tjg. Payang - Sg. Balok	7.02	11.92	22.46	24.94	32.65
7	Sg. Balok - Sg. Karang	8.68	21.96	29.66	30.55	35.53
8	Sg. Karang - Batu Hitam	0	4.43	6.71	7.98	10.79
9	Batu Hitam - Kg. Beserah	0.55	15.56	19.63	24.27	26.90
10	Kg. Beserah - Tjg. Pelindung	2.72	8.79	12.28	12.50	13.28
11	Tjg. Pelindung - Tjg. Tembeling	2.20	5.54	8.26	11.47	11.73
12	Tjg. Tembeling - Sg. Kuantan	51.11	67.17	71.76	77.87	82.90
13	Sg. Kuantan - Tjg. Lumpur	0	2.08	5.71	4.24	9.47
14	Tjg. Lumpur - Kg. Kempadang	15.07	21.91	34.97	32.55	51.39
15	Kg. Kempadang - Sg. Dua	6.83	16.37	40.69	27.63	40.69
16	Sg. Dua - Sg. Penur	102.42	118.13	131.62	142.36	194.08
17	Sg. Penur - Cherok Paloh	51.11	55.07	56.25	67.54	70.14
18	Cherok Paloh - Kuala Pahang	64.14	157.27	230.55	282.55	292.38

According to the Integrated Shoreline Management Plan (ISMP) for Northern Pahang Coastline in 2002, the Kuantan Port had been protect-ed by the construction of breakwaters were extended towards the south of the port. The effect of such construction, Teh Tiong Sa, (2011) re-vealed that the process of erosion and reclamation has occurred in the northern part of the beach caused by the reflection of waves from the wall breakwater. Overall, the findings have found an increase in sea level on Cherating to Pekan show a significant impact on MU 1 (Tjg. Cherating - Sg. Cherating), MU 12 (Tjg. Tembeling - Sg. Kuantan) and MU 16 (Sg. Dua - Sg. Penur). Increasing sea level rise will also result in infrastructures such as schools, community halls, religious places and others contained in the study area were also affected.

The impact of sea level rise in terms of socio-economic

Tourism and Recreation

The area of Cherating to Pekan consists of sand and a bit muddy (Mohd et al., 2018). This causes the Pahang beach such as MU 1 (Tjg. Cherating - Sg. Cherating), MU 12 (Tjg. Tembeling - Sg. Kuantan), MU13 (Sg. Kuantan - TJG. Lumpur) and MU 16 (Sg. Dua - Sg. Penur) became attract for tourists from local and abroad (Azid et al., 2015). The variety of leisure activities available and clean beaches are factors in the choice among travelers to come there. In addition, 36 villages in this study, there were more than 64% of the coastal area, consists of accommodation for tourists. There among of coastal communities' households make their home as a homestay for tourists to earn extra income households. Instead of simulating the hydrodynamic effect, inundation was more pronounced in the MU 12 (Tjg. Tembeling - Sg. Kuantan) and MU 16 (Sg. Two - Sg. Penur), where the area of inundation each between 51.11 ha to 82.90 ha and 102.42 ha to 194.08 ha. In addition, these regions, especially Teluk Cempedak and Pantai Sepat, which are categorized as an area of wide beaches and fine sand.

Small and medium enterprises (SMEs)

There are 12 villages that involve small and medium enterprises such as retail stores, wholesale markets and small-medium industries. Among the 12 villages that could potentially suffer from inundation such as MU8 (Sg. Karang - Batu Hitam), MU9 (Batu Hitam - Kg. Beserah), MU 15 (Kg. Kempadang - Sg. Dua) and MU 18 (Cherok Paloh - Kuala Pahang). The existence of small and medium enterprises (SMEs) that are built within one kilometer from the coast of the area led to economic activities such as the sale of crackers, fish crackers and woven impacted.

Agricultural Activities

There are several activities undertaken subsistence farming to cater for everyday life. It is estimated that there are only 2.5% of the population residing in Pahang coastline agricultural activities as sources of income such as planting coconut, fruits and palm oil. Kampung Baharu Cherat-ing, Kampung Cherating, Kampung Cherating Lama, Kampung Darat Sungai Ular, Kampong Gebeng, Kampung Sungai Ular, Sungai Dua, Kampung Ketapang, Kampung Sepat Kampung Sungai Penor, Kam-pung Cherok Paloh Kampung Hijrah, Kampung Tebing Tinggi; 13 these villages are an important place for the production of oil that causes the proceeds of the sale of at least RM 500.00 per month. The simulation results of hydrodynamic prove that MU1 (Tjg. Cherating - Sg. Cherat-ing), MU3 (Sg. Ular – Jeti Gebeng), MU15 (Kg. Kempadang - Sg. Dua) and MU17 (Sg. Penur - Cherok Paloh) are risks of inundation by 6.83 ha to 70.14 ha in 2020 to 2100. Meanwhile, the planting of oil palm growing around MU 15 and MU 17 involving Sungai Dua, Kampung Ketapang and Kampung Sepat. The effect of inundation occurring causes yields to local communities affected households for the produc-tion of palm oil between RM 1,000 to RM 2,000 per month.

Conclusions

Studies show that the effects of sea level rise had a negative impact on Cherating to Pekan coast, which results in water overflow problems in coastal areas, coastal erosion and the destruction of ecosystems. The result of the integration of geospatial and hydrodynamic modeling techniques in the study of sea level rise forecast in 2020-2100 revealed that three areas, namely Tanjung Cherating to Sungai Cherating, Tanjung Payang to Sungai Balok, and Cheruk Paloh to Kuala Pahang are categorized highly suffering from the effects of sea level rise. Through interviews in the field, the effects of SLR have affected 80% of the surveyed 36 villages where the main activity is agriculture, small enterprises and tourism. The effect of inundation resulting an impact on the local and state economy, especially the tourism sector.

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NOVEL INSIGHTS INTO THE WATER REUSE STRATEGY IN PADDY FIELD: A PILLARING ARM SUPPORTING THE SUCCESSIVE ESTABLISHMENT OF SUSTAINABLE DEVELOPMENT GOAL (SDG) 6

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Abstract

Agriculture is the largest consumer of water, using 72% of the total worldwide and 87% in developing countries. With the growing water demand for non-agricultural uses, the proportion available for agriculture is projected to decline to 62% worldwide and 73% in developing countries. The present and future food security of Asia depends largely on the irrigated rice production system, with more than 75% of the rice supply comes from 79 million ha of irrigated land. To produce 1 kg of grain, farmers have to allocate 2 to 3 times more water in rice fields than in those growing other cereals, and in Asia, the amount of water applied to irrigate rice fields accounts for approximately 50% of all diverted fresh-water. Actively reducing the amount of water for the cultivation of rice represents a positive societal and economic impact if the water saved is diverted to areas where competition from industry, cities, and the environment is high. There is al-so much evidence that water scarcity already prevails in rice-growing areas, where rice farmers need technologies to cope with water shortage, and ways must be sought to grow rice with less water. However, rice is very sensitive to water stress and attempts to reduce water inputs may result in yield reduction. Accord-ing to the field data, more rice production may be achieved by keeping the paddy field as a pool constantly or intermittently with water on the surface. In this sense, new investments in irrigation and water supply systems will be inadequate for meeting the growing non-agricultural demand on water, and for mitigating the impact of water withdrawals from agriculture. Water recycling and conjunctive use of groundwater are rarely considered in the original design of irrigation schemes. Conclusively, the critical challenge to be overcome is the development of novel treatment technologies and production systems that will allow rice pro-duction to be maintained or increased in the face of declining water availability.

Keywords: Irrigation, Paddy field, Sustainable Development Goal 6, Water reuse, Water security

Introduction

Today, the agricultural paradigm is riding to the sustainability of agricultural productivity and environmental preservation (Lincoln and Ardoin, 2016). Limited freshwater resources supporting the population growth and the degradation of water quality is turning to be a fundamental challenge to the agricultural development (Chow et al., 2017). Particularly rice (Oryza sativa L.) is the staple food for nearly half of the world's population, and positions itself to be the most important ingredient in food compositions throughout South Asia and Africa (Joshi et al., 2015). Despite extensive irrigation and fertilizer application might increase the rice productivity, but this cultivation consumes high volume of water, and induces off-site pollution to the receiving water bodies.

The availability of good quality water resources for rice production are getting scarce in many countries as the development of new water supplies does not keep pace with the rising water needs of industries and municipalities (Chow et al., 2020). Thus, irrigated agriculture is facing the challenge of using less water input, in many cases of poorer quality, to provide food and fiber for an expanding population (Kirby et al., 2017). Some of these water needs can be met by using available water supplies more efficiently, but in many cases, it will be necessary to the viable application use of municipal wastewaters and irrigation drainage waters.

Wastewater reuse, including surface and subsurface agriculture drainage water, storm runoff, sewerage effluent and industrial wastewater recycling, is in widespread use as a key alternative water source of supplementing the paddy water supply, as it provides an improvement to productivity and environmental benefits, and consuming agricultural products irrigated with wastewater is a common practice for more than 10% of the world population (Jeong et al., 2016). In addition, reusing wastewater for agriculture has several advantages, particularly in reducing the amount of effluent discharged into receiving water bodies, nutrient recovery as fertilizers, and increase crop production (Table 1).

In contrast, irrigation water quality could demonstrate potentially detrimental effects on the soil, crops, and downstream water quality, and the water quality must be strictly controlled to avoid the possible accumulation of hazardous substances, which are harmful for crop growth, the potential damage to soil by the transformation of its physical and chemical characteristics (Xu et al., 2010) and microbial infection (Forslund et al., 2010). To ensure the environmental sustainability, land application of wastewater reuse must be managed in a way these adverse effects could be minimized. While the effects of industrial and municipal wastewater on agricultural soils have been widely documented, mostly with respect to water contaminants, unique water quality standard and irrigation criteria have not been widely highlighted (Table 1).

Table 1. Advantages and challenges of water reuse as a source of irrigation water.

No.	Advantages	Disadvantages
1.	Increase crop yield	Detrimental effects on soil, crops, and downstream water quality
2.	Effluent load reductions for suspended solid and total phosphorus	Heavy metals, pesticides, pharmaceuticals pollutants
3.	Aids purification of the agricultural drainage water and preservation of the riceland ecosystem	Toxicological effects
4.	Reduction of the amount of return flow	
5.	Increase reuse of return flow and alleviate local water needs	
6.	Reduce fertilizer application	
7.	Reduce the amount of effluent from wastewater treatment plants	

The Present Status of the World Market of Rice Crop

Rice is one of the major crops grown throughout the world (Chandler, 2019), sharing equal importance with wheat as the principal staple food and a provider of nourishment for the world's population. Covering 1% of the earth's surface, rice is now a way of life, being grown on every continent and is deeply embedded in cultures, rituals and myths. In Asia alone, rice constitutes as much as 60 to 70% of the total calorie up-take on average for more than 2000 million people (Foo and Hameed, 2009). According to the statistical data of Food and Agriculture Organization (FAO), the global annual paddy production was reported at 582 million tones, cultivated in 171 million hectares of land (Stefani et al., 2005) From merely a total rice use of 61.5 kg per capita in the 1970s, today the world is exhibiting a necessity of 85.9 kg per capita, of which in some countries, per capita rice consumption is declining amidst the rising incomes (Foo and Hameed, 2011).

Irrigation

Irrigation is always synonym with agriculture. It is a science of artificial application of water to the land or soil. The main idea behind irrigation systems is that the lawns and plants are maintained with the minimum amount of water required. Irrigation has been used for many purposes, among them are for maintenance of landscapes and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. However, when relates to agriculture, irrigation is one of a major section to assist in the growing of agricultural crops. Additionally, irrigation protect plants against frost, suppress weed growing in grain fields, and may assist in preventing soil consolidation. The implementation of an irrigation system will help to conserve water, while saving time, money, preventing weed growth and increasing the growth rate of lawns, plants and crops.

Water Reuse as a Source of Irrigation Water

Wastewater has been used extensively as a source of irrigation water in water-shortage countries, since irrigation water does not usually require high-grade water quality as compared to the drinking water. Apart from meeting the water needs at peak demand periods, water reuse is a quick-response water supply solution during dry spells, increasing both the water reliability and crop security. Besides from the fact that the amount of return flow drained out of the irrigation system was reduced when drainage water was reused for irrigation, the effluent load reductions for suspended solid and total phosphorus owing to water reuse were consistently high. Hence, water reuse could not only meet with the irrigation water needs, but also aids purification of the agricultural drainage water and preservation of the riceland ecosystem.

Under a series of water management strategies, about 87% of the total volume of return flow can supplement industrial water needs which decreases local water needs by about 22.4% (Chang et al., 2010). The strategies include increasing the volume of return flow through deep water management practices, stabilizing the reuse of return flow in the purification unit through the regulated large-capacity pond downstream, and harmonizing the supply-and-demand gap through a suitable cultivated paddy scale of the crop rotation pattern.

Net water consumption in wetland paddy irrigation takes place through evapotranspiration ET crop (t) and the growth of plant bodies. The other part of the irrigation water moves downstream after infiltrating the soil or flowing directly into adjacent drains (Sophocleous, 2002). Accordingly, wetland paddy has a buffer function for water quality (Verhoeven et al., 2006), and the higher water reuse ratio in wetland paddy can reduce the net runoff load to zero (National Institute for Rural Engineering, 2004). Therefore, the water users in downstream areas have the opportunity to reuse the water. The storage of rainfall in wetland paddy by bunds is like an effective rainwater cistern system during the wet season (Ding et al., 2018). Since the water need for urban and industrial water use is growing, the reuse of return flow from wetland paddy to supplement the dramatically increasing water needs is critical.

Besides securing alternative water resources for irrigation, wastewater reuse can have several advantages such as reducing fertilizer application, increasing crop yield, and reducing the amount of effluent from wastewater treatment plants. On the other hand, irrigating with wastewater enriched with nutrients can potentially have detrimental effects on soil, crops, and downstream water quality (Chow et al., 2018). While the effects of industrial and municipal wastewater on agricultural soils have been widely documented, mostly with respect to heavy metal concentrations and toxicological studies, the environmental impacts of irrigating with wastewater on downstream water quality have not been widely investigated (Wicklein and Schiffer, 2002). To ensure environmental sustainability, the impacts of irrigating with reclaimed wastewater on downstream water quality should be investigated before making use of this alternative irrigation water resource.

Considerations of Water Quality Standards for Irrigation Water Reuse

Irrigation water quality criteria

In the case of indirect wastewater reuse, the irrigation water quality is affected by water in which the treated wastewater is diluted such as stream water or lake water. Therefore, to examine the water quality standards for indirect wastewater reuse, irrigation water quality criteria should be significantly considered.

Salinity

Salinity has been deemed as the most important factor of agricultural water quality because high salinity in soil can create a hostile environment for the crop to absorb nutrients and provoke specific ion toxicity (Bauder et al., 2011). The Food and Agriculture Organization (FAO) has established guidelines for agricultural water primarily based on salinity. These guidelines have been modified by Ayers and Westcot in 1985 and are being internationally accepted.

Nutrients

Nitrogen (N) and phosphorus (P) are the primary nutrients for crop growth, but nonetheless when applied excessively could generate a negative effect. Especially for paddy rice, excessive N and P can cause the crop to over-grow which leads to lodging.

Organic matters

Generally, biochemical oxygen demand (BOD5) is used as an index for organic matter. In a high BOD5 environment, oxygen in water is consumed for decomposing organic matters to create an anaerobic state, and, during the process of decomposition, oxides in the soil such as Fe3+, Mn5+, and SO42- consume oxygen to lower the oxidation-reduction potential. Eventually, the generated iron, manganese, and sulfide along with organic acids can disrupt the paddy rice to absorb nutrients.

Hydrogen ion concentrations

Hydrogen ion concentration, represented by pH is an index upon which irrigation water is quickly assessed for its suitability. Normally, the pH of irrigation water ranges from 6.5 to 8.4. The pH outside of the normal range might be suitable for irrigating, but has the potential to cause an imbalance of nutrients or contain poisonous ions. The biggest hazard related to an abnormal pH in water is its effect on irrigation facilities. Exceptionally low pH in irrigation water can expedite the corrosion process of facilities, and irrigation water containing high levels of alkalinity can lower the efficiency of the trickle irrigation system (Bauder et al., 2011).

Trace elements

Trace elements are necessary for crop growth but when the amount of heavy metals in irrigation water is excessive, it can cause danger. Copper (Cu) can cause leaf chlorosis as well as the suppression of root growth. Zinc (Zn) and arsenic (As) both have side effects of stem chlorosis and root growth suppression. Aluminum (Al), in acid soil, can decrease productivity. Lead (Pb), cyan (CN), and cadmium (Cd) are normally strictly restricted since, when dissolved in water or soil, they can be accumulated in the crop and in turn harmful to the human body. The FAO's irrigation water quality guidelines, therefore, has set limits on concentrations of trace elements in irrigation water (Ayers and Westcot, 1985).

Conclusions

Wastewater reuse has shown the great potential as a viable solution to the agricultural water shortage problems. It can be estimated that the long-term development of eco-friendly paddy wastewater reuse treatment technique will allow for the reclamation and reuse of at least 10% of the total amount of wastewater, or approximately 600 million m3/ year throughout the world.

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A STUDY ON THE NET MATERIALS AS A POTENTIAL MATERIAL FOR FOG HARVESTER

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Abstract

Water resources security is one of the national agendas that being highlighted that needs to take into consideration, where, it was being projected to be limited in the future if no further actions are being carried out to protect our water resources. The unfavorable climate as well as human activities have deteriorating our water resources and it resulted in water scarcity during the hot or drought season. Therefore, the government has taken a serious action by planning several potential plans as stated in the Malaysia Eleven Plan (2016-2020) to strengthen the resilience against climate and natural. Fog is a potential source of water that could be exploited using the innovative technology of fog collection. Fog collection has never been studied in Malaysia and its potential is never being explored. Thus, the aim of this study to investigate the potential of fog harvesting in two locations in Malaysia and to investigate the factors that affect the fog harvesting performance. The fog harvesting system was designed based on a previous study by using three different net types (plastic shade net, fiberglass mesh net, and aluminum mesh) with different mesh sizes. While for meteorological data, five (5) parameters were measured such as rainfall, temperature, humidity, wind speed, and wind direction. Moreover, the effect of altitude was evaluated to determine the impact on the quality as well as a quantity of fog water. Based on the result, fiber-glass mesh shows the highest efficiency in terms of water collected compared with aluminum and plastic shaded meshes. Moreover, the higher altitude also influences the volume of capture volume of water where the high altitude recorded a high volume of water compared to a lower elevation. Thus, the result explicitly shows that the fog harvesting could be one of the potential alternative water resources. Besides, this study could be contributing to further fog harvesting research in Malaysia.

Keywords: Harvesting, Alternative Water Resource, Mesh, Rainfall, Humidity.

Introduction

Water is one of the essential resources that need to be protected because it was categorized as one of the important resources needed by living things especially humans. The availability and adequacy of freshwater resources are one of the factors in household livelihood improvement and economic development. However, the availability of freshwater resources has faced a serious depletion due to population growth, expansion of agriculture, and industrial areas. Moreover, deterioration of water quality was boost by the increase of domestic, agriculture, and industrial effluent and other human activities (Adnan et al., 2011). The Food and Agricultural Organization of the United Nations (FAO) predicts that nearly 2 billion people will be living in water-scarce areas by 2025 and that two-thirds of the world's population will be living in areas under water stress. Thus, they have to

address climate-related security risks through concrete action – voices from the field highlighted the complex effects of climate change on peace and security through its interplay with socio-economic, political, and demographic factors (United Nations, 2019). It has been estimated that in the next 15 years, areas in Asia, Africa, and the Middle East will be classified as having absolute water scarcity (Abdul-Wahab & Lea, 2008).

In Malaysia like other countries around the world, which experienced a change of season in a year. This condition could lead to several disasters such a flood, drought, El-Nino, and so forth. All these disasters need to be addressed and solve wisely to avoid further damage to our resources. Even though Malaysia was blessed to receive an abundance of water yearly, but we still have a water shortage problem during a drought season. These conditions could tell us that the management of water resources in this country are still can be improved and needed further sustainable management (Nda et al., 2018). The recent drought season has recorded a serious water rationing at several locations in Malaysia. At the moment, we are heavily dependent on the river water which is encompassed by 97% of our water resources. The exploration of other resources such as groundwater, brackish water, rainwater, and fog water is needed to support and balance the usage of water. All these resources are not fully explored and utilized in Malaysia that could be a huge potential to be a good compliment to river water.

The collection of fog using fog harvesting systems is one of the alternative water resource collections that has attracted increasing attention over the past few decades. The collection of fog water can be developed by using simple technology as well as advanced technology (Schunk et al., 2018). A mesh is exposed to the atmosphere and the fog is pushed through the mesh by the wind. A fraction of the fog droplets are deposited on the mesh material by impaction. When more and more fog droplets deposit, they combine to form larger droplets run down the mesh materials into gutters and eventually into a storage tank. Differences between various fog collector designs exist regarding their size and shape, as well as the mesh material used (Schunk et al., 2018)(Qadir et al., 2018). The Standard Fog Collector (SFC) is mainly used in exploratory studies to evaluate the amount of fog water that can be collected at given sites (Jana Olivier, 2004).

The fog harvesting has been implemented in various locations in the world to test the applicability of this system. Some of the locations or regions that have been installed with the fog harvesting such as South America (Schemenauer & Cereceda, 1994), South Africa (J. Olivier, 2002), Oman (Abdul-Wahab & Lea, 2008), Yemen (Abualhamayel & Gandhidasan, 2010) and, Colombia (Corell et al., 2010). This could give some insight to us to study the potential of this harvesting system to be implemented in Malaysia especially to the remote area that having a problem with water resources.

Therefore, this study was conducted to determine the potential and performance of fog harvesting in Malaysia since there is no comprehensive study was conducted. The result of this study could serve as a baseline study for further study on fog harvesting in Malaysia.

Materials and Methods

Study area

Two study locations were selected for this study located at Parit Daun and Bukit Perdana which both locations located in Batu Pahat district. These two locations represent low altitude (Parit Daun, 5m) and high altitude (Bukit Perdana, 35m) respectively. These areas received about 2100 – 2500 mm of rainfall every year with an average temperature of 28oC. The main land-use type for Parit Daun is Palm Oil estate while Bukit Perdana is a mixed development and virgin forest. Figure 1 shows the location of the study area.

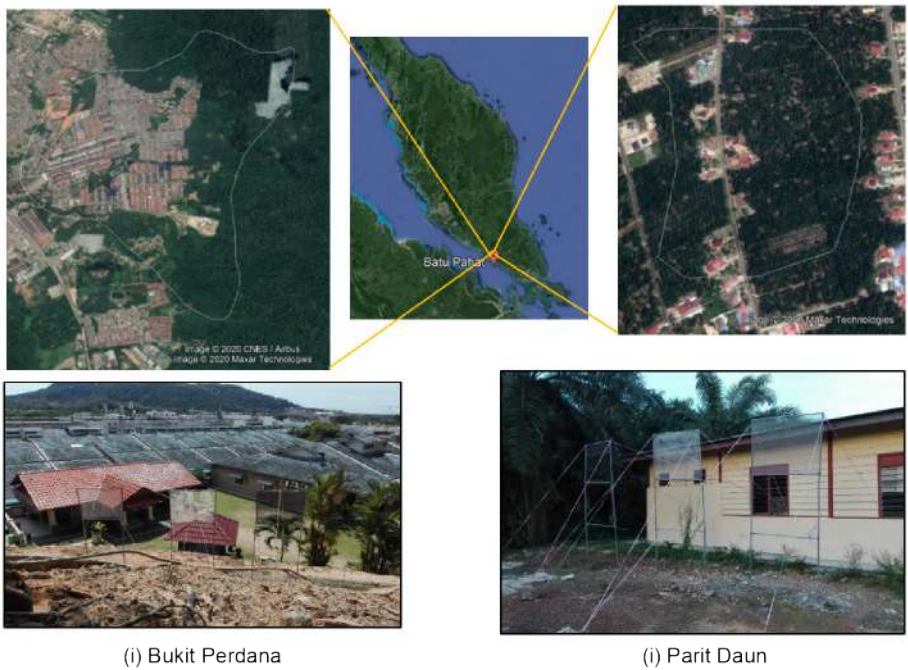


Figure 1. Location of the study area.

Fog Harvester Frame and Net Materials

For this study, the fog harvester was divided into three parts which are (i) net frame, (ii) body/collector part, and (iii) foundation. The development of fog harvester design was referred to previous study. After critical review, the fog harvester that used in this study is a 1m x 1m dimension as shown in Figure 2. For the net selection, three types of nets were used which are (i) plastic shade net, (ii) fiberglass mesh net, and (iii) aluminum mesh net. These nets were installed at the harvester frame as shown in Figure 2. The selection of these nets is based on the availability of the nets on the market.

The mesh is placed tightly on the frame to avoid the loss of the collector fog. As water collects on the net, droplets join to form larger drops that fall under gravity toward a trough located at the bottom of the panel. The water is then flowing through a PVC pipe to a storage tank capacity of 30 L located at the bottom. A suitable water supply system must be designed to transfer the water from the trough to the reservoir or storage.

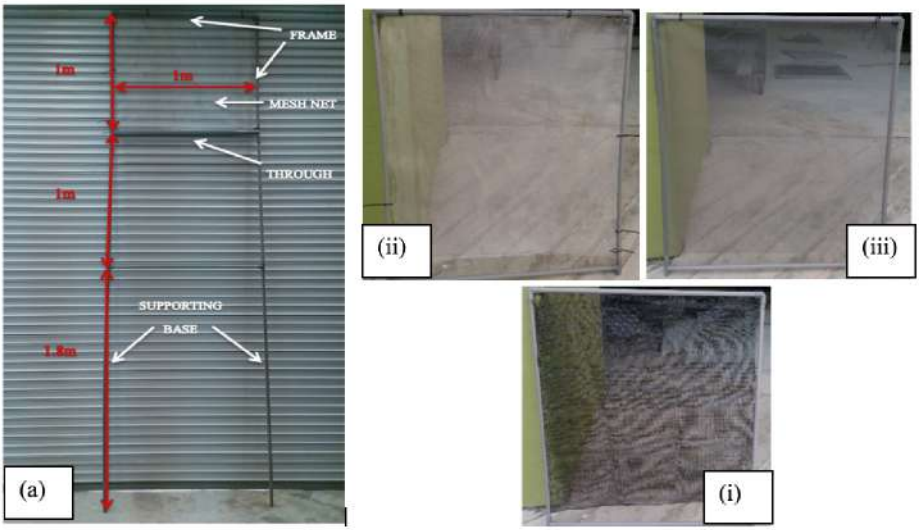


Figure 2. (a) Fog harvester frame with 1m x 1m, and net types used (i) plastic shade net, (ii) fiberglass mesh net, and (iii) aluminum mesh net

Data collection

Hydrological Data

Daily monitoring of hydrological data was observed and collected. The automatic data logger was installed on-site to collect the rainfall, temperature, humidity, wind speed, and wind speed direction by using the HOBO weather station RX3000 Datalogger. The data were observed and collected for about 1 month from 30 October 2017 – 30 Nov. 2017. These data were being analyzed to determine the effectiveness of the net type as well as the altitude factor.

Water Volume

As the water is flowing from net mesh to a PVC pipe and settled in a storage tank at the bottom of the fog harvester. The volume of the collected water was recorded manually by measuring the water in the collection bucket every day. The bucket will be emptied after the collection of water being measured. To determine the efficiency of the net as a fog harvester, the volume of water collected from each net type was compared.

Results and discussion

Based on the collected data, there are slightly different in data between these two sites where Parit Daun shows a lower humidity reading compared with Bukit Perdana. The average humidity reading for Parit Daun is 63±15% while Bukit Perdana is about 67±24%. This result shows a good agreement with the local condition of the study area where Bukit Perdana located at a higher altitude compared to Parit Daun.

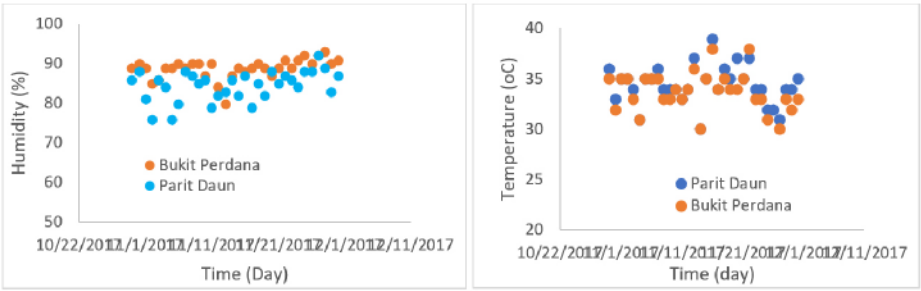


Figure 3. Humidity and temperature data for both study locations during the study period.

For the rainfall and temperature data, there are no significant differences in rainfall amount and average temperature between these two study areas because the distance between these two locations is about 20km. The total rainfall within a month is about 123mm, the highest rainfall depth is about 8 mm as shown in Figure 3. It was observed that the number of rainy days and the intensity of rainfall plays an important role in contributing to generating extra water collection compared with no rainy day.

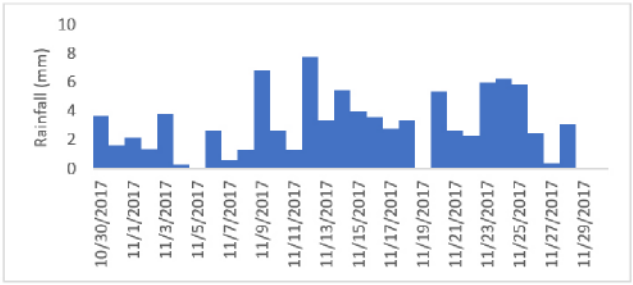


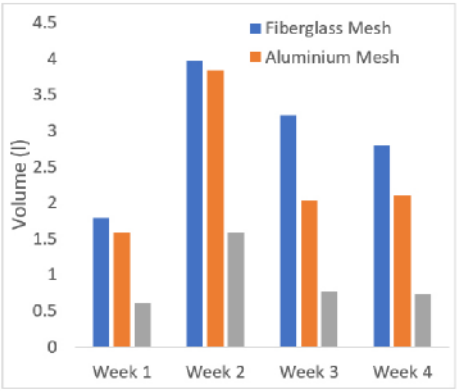
Figure 4. The rainfall data during the study period

To determine the efficiency of net types, the volume of collected water was compared. Based on the result, it clearly shows that the volume of water collected at the Bukit Perdana is higher compared with Parit Daun (Table 1). This indicated that the altitude could contribute a significant factor in determining the volume of water. A study by (Schemenauer & Cereceda, 1994) also mentions the location of fog harvester which located at a higher location produces more water. Moreover, the area with high humidity also could produce more volume of water. On the other hand, a high number of rainy days also contribute to the high volume of water where the volume of collected water is higher during the rainy day.

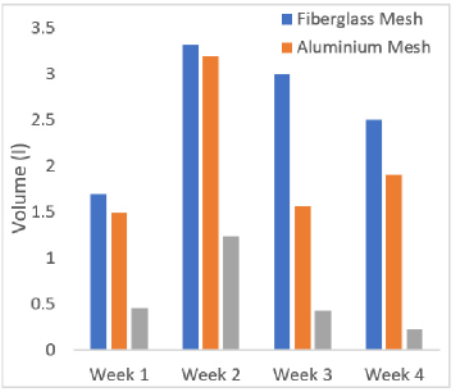
The selection of net types as media to capture the fog also contributes to the volume of water. In this study, three types of nets were tested, and it clearly shows that the fiberglass net shows the highest efficiency follow by aluminum and plastic shaded nets. Figure 5 shows the result of water volume for both sites. Appropriate tuning of the wetting characteristics of the surfaces, wire spacing all leads to more efficient fog collection (Park et al., 2013). On the other hand, the mesh shape also contributes to the efficiency of the water collection. According to the study by (Shanyengana et al., 2003), they have mentioned that the shape of triangle mesh contributes to the high efficiency of fog collection compared to rectangular mesh shape.

Table 1. The volume of water collected weekly for each site.

Net Material	Parit Daun				Bukit Perdana			
	Week 1	Week 2	Week 3	Week 4	Week 1	Week 2	Week 3	Week 4
Fiberglas	1.78	3.97	3.21	2.80	1.68	3.31	3.00	2.50
Aluminium	1.58	3.842	2.03	2.10	1.48	3.18	1.56	1.90
Plastic	0.61	1.58	0.76	0.73	0.45	1.23	0.43	0.23



(i) Bukit Perdana



(i) Parit Daun

However, this result needs further research since the arrangement of mesh size is a difference and this could contribute to the water capture capacity. The bigger mesh has a low water capture efficiency compared to a small mesh size. A study by (Schunk et al., 2018) has concluded in their study that the mesh arrangement and mesh size have played a significant factor in determining the efficiency of the performance of media for fog harvester. Thus, further research on the same size mesh and different types of materials need to be conducted to further enhance the finding from this study.

Conclusion

As a conclusion, three types of nets used in this study can be used as a fog harvester material. However, the efficiency of each material is different where the fiberglass shows a better water capture efficiency compared with aluminum and plastic shaded nets. On the other hand, the location of fog harvester also influences the volume of collected water where higher altitude areas could produce more fog compared to low land areas.

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