

**ADSORPTION OF PHENOL FROM AQUEOUS SOLUTIONS
USING INCINERATED SEWAGE SLUDGE**

By

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ABSTRACT

A study had been carried out to determine the potential use of sewage sludge ash (SSA) as an adsorbent in removing phenol from aqueous solution. Parameters which contributed to affect phenol removal were initial phenol concentration, contact time, adsorbent dosage, pH and particle size of adsorbent. Results showed that the adsorption capacities of adsorbent (K_f) for phenol decreased from 14.89 mg/g to 0.68 mg/g as initial phenol concentration increased from 0.1 mg/l to 5.0 mg/l. Results revealed that solution with higher initial phenol concentration required longer time to reach equilibrium state. Adsorption capacity of adsorbent (K_f) decreased from 14.89 mg/g to 0.66 mg/g as contact time increased from 240 minutes to 1200 minutes. Furthermore, pH was found to affect the adsorption capacity where as pH decreased from original (9 - 12) to neutral (7 - 8), adsorption capacity of adsorbent increased from 0.68 mg/g to 3.0 mg/g. Moreover, it was shown that as particle size of adsorbent decreased from 150 - 212 μm to 63 - 149 μm , adsorption capacity of adsorbent (K_f) was decreased from 2.06 mg/g to 0.68 mg/g. Adsorption isotherm analysis showed that the experimental data fit Freundlich model in most conditions.



ABSTRAK

Kajian telah dilakukan untuk mengetahui potensi abu enapcemar kumbahan dalam penyingkiran "phenol" daripada larutan berair. Parameter-parameter yang mempengaruhi penyingkiran 'phenol" terdiri daripada kepekatan awal "phenol", masa tindakbalas, dos penyerap, nilai pH dan saiz butiran penyerap. Keputusan menunjukkan bahawa kapasiti penyerapan abu enapcemar (K_f) bagi "phenol" menurun daripada 14.89 mg/g kepada 0.68 mg/g apabila kepekatan awal "phenol" meningkat daripada 0.1 mg/l kepada 5.0 mg/l. Keputusan mendedahkan bahawa larutan dengan kepekatan awal "phenol" yang lebih tinggi memerlukan lebih lama masa untuk mencapai keadaan keseimbangan. Kapasiti penyerapan bagi abu enapcemar (K_f) menurun daripada 14.89 mg/g kepada 0.66 mg/g apabila masa tindakbalas meningkat daripada 240 minit kepada 1200 minit. Selain itu, nilai pH didapati mempengaruhi kapasiti penyerapan iaitu apabila nilai pH menurun daripada keadaan semulajadi (9 - 12) kepada neutral (7 - 8), kapasiti penyerapan abu enapcemar meningkat daripada 0.68 mg/g kepada 3.0 mg/g. Selain daripada itu juga, telah ditunjukkan bahawa apabila taburan saiz butiran abu enapcemar menurun daripada 150 - 212 μm kepada 63 - 149 μm , kapasiti penyerapan abu enapcemar (K_f) menurun daripada 2.06 mg/g kepada 0.68 mg/g. Analisis penyerapan isoterma menunjukkan bahawa data ujikaji sesuai dengan model Freundlich dalam kebanyakan keadaan.

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I sincerely hope that this study will be a contribution toward the goal of better engineering in the field of water quality. I constantly remind myself of the following quote from Baba Diodum; "In the end we will conserve only what we love, we will love only what we understand and we will understand only what we are taught".

Should there be any omissions, I would like to offer my apologies in advance. There is little, apart from mistakes, for which I can claim credit. My contribution, if any, is in correlation and interpretation of the available information. Even on this there are bound to be differing views, because the entire scientific truth on the subject has not yet been revealed, and interpretations at variance do not imply criticism or disrespect.

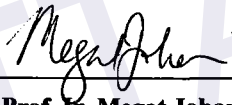
Finally, I would like to thank all people, whose have been helping me in this study and especially to my parent for giving me support in my life.

I certify that an Examination Committee met me on **3 November 2004** to conduct the final examination of **Wan Afnizan Bin Wan Mohamed** on his **Masters of Science** thesis entitled “**Adsorption of Phenol from Aqueous Solution Using Incinerated Sewage Sludge**” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:



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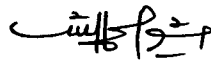
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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



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TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	iv
ACKNOWLEDGEMENTS	v
APPROVAL 1	vi
APPROVAL 2	vii
DECLARATION	viii
LIST OF TABLES	xiii
LIST OF FIGURES	xvii
LIST OF SYMBOLS	xxii

CHAPTER

1	INTRODUCTION	1
2	LITERATURE REVIEW	4
2.1	Phenols	4
2.2	Phenol Pollution in Malaysia	5
2.3	Effect of Phenol Pollution to Human Health	10
2.4	Effect of Phenol Pollution to Environment	11
2.5	Treatment Processes Used for Phenol Removal	12
2.6	Adsorption Process	14
2.6.1	Bulk Solution Transport	14
2.6.2	External (Film) Resistance to Transport	14
2.6.3	Internal (Pore) Transport	15
2.6.4	Adsorption	15
2.7	Adsorption Isotherm	16

2.8	Previous Studies on Phenol Removal Using Adsorption	18
2.8.1	Conventional Activated Carbon	18
2.8.2	Silica Gel Sludge	20
2.8.3	Peat, Fly Ash and Bentonite	21
2.8.4	Bentonite	22
2.8.5	Fly Ash (F.A) and Impregnated Fly Ash (I.F.A)	24
2.8.6	Dried Activated Sludge	27
2.8.7	Locally Available Materials	29

3 MATERIAL AND METHOD 32

3.1	Adsorbent Preparation	32
3.2	Particle Size Analysis of Adsorbent	33
3.3	Phenol Solution Preparation	35
3.4	Design of Experiment	37
3.4.1	Effect of Initial Phenol Concentration	39
3.4.2	Effect of Contact Time	39
3.4.3	Effect of Adsorbent Dosage	40
3.4.4	Effect of pH	40
3.4.5	Effect of Particle Size	41
3.5	Condition That Was Fixed During Conducting Experiment	41
3.6	Analysis of Phenol	43
3.7	Standard Calibration Curve for Phenol Measurement	47



PT TUNJUNGU TUN AMINAH
PERPUSTAKAAN TUNJUNGU TUN AMINAH

4	RESULTS AND DISCUSSION	49
4.1	Particle Size distribution for Sewage Sludge Ash	50
4.2	Efficiency of Adsorbent	51
4.2.1	Effect of Initial Phenol Concentration	51
4.2.2	Effect of Adsorbent Dosage	56
4.2.3	Effect of Contact Time	59
4.2.4	Effect of pH	62
4.2.5	Effect of Particle Size	67
4.3	Adsorption Modeling	72
4.3.1	Effect of Initial Phenol Concentration	72
4.3.2	Effect of Adsorbent Dosage	75
4.3.3	Effect of Contact Time	76
4.3.4	Effect of pH	78
4.3.5	Effect of Particle Size	81
5	CONCLUSION AND RECOMMENDATIONS	84
5.1	Efficiency of Adsorbent	84
5.2	Adsorption Modeling	85
	REFERENCES	88
	APPENDICES	92
A	Experimental Data, Tables and Results	93
A.1	Raw Data for Initial Phenol Concentration, Contact Time and Adsorbent Dosage Effect	94
A.2	Raw Data for particle Size Effect	99
A.3	Raw Data for pH Effect	101



PTTA
PERPUSTAKAAN TUNJUNGAN AMINAH

A.4	Efficiency of Adsorbent for Effect of Initial Phenol Concentration	103
A.5	Efficiency of Adsorbent for Effect of Adsorbent Dosage	107
A.6	Efficiency of Adsorbent for Effect of Contact Time	110
A.7	Efficiency of Adsorbent for Effect of pH	113
A.8	Efficiency of Adsorbent for Effect of Particle Size	114
A.9	Adsorption Isotherm for Effect of Initial Phenol Concentration	115
A.10	Adsorption Isotherm for Effect of Adsorbent Dosage	118
A.11	Adsorption Isotherm for Effect of Contact Time	121
A.12	Adsorption Isotherm for Effect of pH	124
A.13	Adsorption Isotherm for Effect of Particle Size	126
B	Adsorption Modeling Graph	128
B.1	Effect of Initial Phenol Concentration	129
B.2	Effect of Adsorbent Dosage	131
B.3	Effect of Contact Time	133
B.4	Effect of pH	135
B.5	Effect of Particle Size	136
C	Laboratory Pictures	137
	BIODATA OF THE AUTHOR	142



PTTA
PERPUSTAKAAN TUNKU AMINAH

LIST OF TABLES

TABLE		PAGE
Table 2.1	Classification for Interim National Water Quality Standards for Malaysia (INWQS).	6
Table 2.2	Effluent discharge standards to Malaysian inland waters.	7
Table 2.3	Groundwater sampling by landuse category in Peninsular Malaysia, 2001.	8
Table 2.4	Concentration of non-compliance of phenolics compound in groundwater from Malaysia.	9
Table 3.1	Condition that was fixed during phenol removal study.	42
Table 4.1	Particle size distribution of sewage sludge ash.	50
Table 4.2	Sorption isotherm parameters for different initial phenol concentration (Particle Size = 63 μm - 149 μm ; pH = Original (9-12).	72
Table 4.3	Sorption isotherm parameters for adsorbent dosage (Particle Size = 63 μm - 149 μm ; pH = Original (9-12).	75
Table 4.4	Sorption isotherm parameters for different contact time (Particle Size = 63 μm - 149 μm ; pH = Original (9-12).	76
Table 4.5	Sorption isotherm parameters for different pH values (Co = 5.0 mg/l; Particle Size = 63 μm - 149 μm).	78
Table 4.6	Sorption isotherm parameters for different particle size range (Co = 5.0 mg/l; T = Room (28 ± 2 °C); pH = Original (9-12).	81
Table A.1	Raw Data : Co = 0.02 mg/l; pH = Original (9-12); Particle Size = 63 - 149 μm .	94
Table A.2	Raw Data : Co = 0.1 mg/l; pH = Original (9-12); Particle Size = 63 - 149 μm .	95
Table A.3	Raw Data : Co = 5.0 mg/l; pH = Original (9-12); Particle Size = 63 - 149 μm .	97
Table A.4	Raw Data - Co = 5.0 mg/l; pH = Original (9-12); Particle Size = 150 - 211 μm .	99

Table A.5	Raw Data - Co = 5.0 mg/l; pH = Neutral (7-8); Particle Size = 63 - 149 μm .	101
Table A.6	Effect of Initial Phenol Concentration (Adsorbent dosage = 0.5 g; pH = Original (9-12); Particle size = 63 - 149 μm).	103
Table A.7	Effect of Initial Phenol Concentration (Adsorbent dosage = 2.0 g; pH = Original (9-12); Particle size = 63 - 149 μm).	104
Table A.8	Effect of Initial Phenol Concentration (Adsorbent dosage = 4.0 g; pH = Original (9-12); Particle size = 63 - 149 μm).	105
Table A.9	Effect of Initial Phenol Concentration (Adsorbent dosage = 7.0 g; pH = Original (9-12); Particle size = 63 - 149 μm).	106
Table A.10	Effect of adsorbent dosage (Initial phenol concentration = 0.02 mg/l; pH = Original (9-12); Particle size = 63 - 149 μm	107
Table A.11	Effect of adsorbent dosage (Initial phenol concentration = 0.1 mg/l; pH = Original (9-12); Particle size = 63 - 149 μm).	108
Table A.12	Effect of adsorbent dosage (Initial phenol concentration = 5.0 mg/l; pH = Original (9-12); Particle size = 63 - 149 μm).	109
Table A.13	Effect of contact time (Initial phenol concentration = 0.02 mg/l; pH = Original (9-12); Particle size = 63 - 149 μm).	110
Table A.14	Effect of contact time (Initial phenol concentration = 0.1 mg/l; pH = Original (9-12); Particle size = 63 - 149 μm).	111
Table A.15	Effect of contact time (Initial phenol concentration = 5.0 mg/l; pH = Original (9-12); Particle size = 63 - 149 μm).	112
Table A.16	Effect of pH (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 0.5 g; Particle size = 63 - 149 μm).	113
Table A.17	Effect of Particle Size (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 0.5 g; pH = Original (9-12).	114

Table A.18	Adsorption Isotherm for Effect of Initial Phenol Concentration Initial Phenol Concentration, $C_o = 0.02$ mg/l (Particle Size = $63 \mu\text{m} - 149 \mu\text{m}$; pH = Original (9-12).	115
Table A.19	Value for Langmuir and Freundlich graph at initial phenol concentration 0.02 mg/l.	115
Table A.20	Adsorption Isotherm for Effect of Initial Phenol Concentration, $C_o = 0.1$ mg/l (Particle Size = $63 \mu\text{m} - 149 \mu\text{m}$; pH = Original (9-12).	116
Table A.21	Value for Langmuir and Freundlich graph at initial phenol concentration 0.1 mg/l.	116
Table A.22	Adsorption Isotherm for Effect of Initial Phenol Concentration, $C_o = 5.0$ mg/l (Particle Size = $63 \mu\text{m} - 149 \mu\text{m}$; pH = Original (9-12).	117
Table A.23	Value for Langmuir and Freundlich graph at initial phenol concentration 5 mg/l.	117
Table A.24	Adsorption Isotherm for Effect of Adsorbent Dosage = 2.0 g; Initial Phenol Concentration = 0.02 mg/l (Particle Size = $63 \mu\text{m} - 149 \mu\text{m}$; pH = Original (9-12).	118
Table A.25	Value for Langmuir and Freundlich graph at adsorbent dosage 2.0 g; initial phenol concentration 0.02 mg/l.	118
Table A.26	Adsorption Isotherm for Effect of Adsorbent Dosage = 7.0 g; Initial Phenol Concentration = 0.1 mg/l (Particle Size = $63 \mu\text{m} - 149 \mu\text{m}$; pH = Original (9-12).	119
Table A.27	Value for Langmuir and Freundlich graph at adsorbent dosage 7.0 g; initial phenol concentration 0.1 mg/l.	119
Table A.28	Adsorption Isotherm for Effect of Adsorbent Dosage = 7.0 g; Initial Phenol Concentration = 5.0 mg/l (Particle Size = $63 \mu\text{m} - 149 \mu\text{m}$; pH = Original (9-12).	120
Table A.29	Value for Langmuir and Freundlich graph at adsorbent dosage 7.0 g; initial phenol concentration 5.0 mg/l..	120
Table A.30	Adsorption Isotherm for Effect of Contact Time = 15 minutes, Initial Phenol Concentration = 0.02 mg/l (Particle Size = $63 \mu\text{m} - 149 \mu\text{m}$; pH = Original (9-12).	121
Table A.31	Value for Langmuir and Freundlich graph at contact time 15 minutes.	121

Table A.32	Adsorption Isotherm for Effect of Contact Time = 240 minutes, Initial Phenol Concentration = 0.1 mg/l, (Particle Size = 63 μm - 149 μm ; pH = Original (9-12).	122
Table A.33	Value for Langmuir and Freundlich graph at contact time 240 minutes.	122
Table A.34	Adsorption Isotherm for Effect of Contact Time = 1200 minutes, Initial Phenol Concentration = 5.0 mg/l, (Particle Size = 63 μm - 149 μm ; pH = Original (9-12).	123
Table A.35	Value for Langmuir and Freundlich graph at contact time 1200 minutes.	123
Table A.36	Adsorption Isotherm for Effect of pH = Adjusted to Normal (7-8), Co = 5.0 mg/l (Particle Size = 63 μm - 149 μm .	124
Table A.37	Value for Langmuir and Freundlich graph at Original pH (9-12).	125
Table A.38	Value for Langmuir and Freundlich graph at Normal pH (7-8).	125
Table A.39	Adsorption Isotherm for Effect of Particle Size = Adjusted to 150 μm - 212 μm , Co = 5.0 mg/l (T = Room (28 \pm 2 $^{\circ}\text{C}$); pH = Original (9-12).	126
Table A.40	Value for Langmuir and Freundlich graph for 63 - 149 μm .	127
Table A.41	Value for Langmuir and Freundlich graph for 150 - 212 μm .	127

LIST OF FIGURES

FIGURE		PAGE
Figure 3.1	(a) Dewatered sewage sludge as collected (b) Sewage sludge after incineration at 900°C for 3 hours.	33
Figure 3.2	Experiment to select the best particle sizes for phenol removal study (from left: pan - 37 μm , 38 μm - 62 μm , 63 μm - 149 μm , 150 μm - 211 μm , 212 μm - 299 μm , 300 μm - 424 μm , > 425 μm).	34
Figure 3.3	Experiment to select the best particle sizes for phenol removal study, after 1 hour left. (From left: pan - 37 μm , 38 μm - 62 μm , 63 μm - 149 μm , 150 μm - 211 μm , 212 μm - 299 μm , 300 μm - 424 μm , > 425 μm).	34
Figure 3.4	Particles sizes of adsorbent.	35
Figure 3.5	Summary of experimental design for phenol removal study	38
Figure 3.6	Amber color appears inside solution when phenol is present. Dark color indicates that higher phenol concentration in solution. (Initial phenol concentration = 5.0 mg/l, pH = Original).	45
Figure 3.7	Phenol was extracted from solution using chloroform (bottom layer).	45
Figure 3.8	Final product of chloroform extract ready to be analyzed by spectrophotometer.	46
Figure 3.9	Standard calibration curve for phenol concentration measurement.	47
Figure 4.1	Percentage of particle size of sewage sludge ash retained from sieve analysis.	50
Figure 4.2	Effect of initial phenol concentration on phenol removal efficiency (Adsorbent dosage = 0.5 g; pH = Original (9-12); Particle size = 63 - 149 μm).	52
Figure 4.3	Effect of initial phenol concentration on phenol removal efficiency (Adsorbent dosage = 2.0 g; pH = Original (9-12); Particle size = 63 - 149 μm).	53

Figure 4.4	Effect of initial phenol concentration on phenol removal efficiency (Adsorbent dosage = 4.0 g; pH = Original (9-12); Particle size = 63 - 149 μ m).	54
Figure 4.5	Effect of initial phenol concentration on phenol removal efficiency (Adsorbent dosage = 7.0 g; pH = Original (9-12); Particle size = 63 - 149 μ m).	55
Figure 4.6	Effect of adsorbent dosage on phenol removal efficiency (Initial phenol concentration = 0.02 mg/l; pH = Original (9-12); Particle size = 63 - 149 μ m).	56
Figure 4.7	Effect of adsorbent dosage on phenol removal efficiency (Initial phenol concentration = 0.1 mg/l; pH = Original (9-12); Particle size = 63 - 149 μ m).	57
Figure 4.8	Effect of adsorbent dosage on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; pH = Original (9-12); Particle size = 63 - 149 μ m).	58
Figure 4.9	Effect of contact time on phenol removal efficiency (Initial phenol concentration = 0.02 mg/l; pH = Original (9-12); Particle size = 63 - 149 μ m).	59
Figure 4.10	Effect of contact time on phenol removal efficiency (Initial phenol concentration = 0.1 mg/l; pH = Original (9-12); Particle size = 63 - 149 μ m).	60
Figure 4.11	Effect of contact time on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; pH = Original (9-12); Particle size = 63 - 149 μ m).	61
Figure 4.12	Effect of pH on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 0.5 g; Particle size = 63 - 149 μ m).	63
Figure 4.13	Effect of pH on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 2.0 g; Particle size = 63 - 149 μ m).	64
Figure 4.14	Effect of pH on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 4.0 g; Particle size = 63 - 149 μ m).	65
Figure 4.15	Effect of pH on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 7.0 g; Particle size = 63 - 149 μ m).	66

Figure 4.16	Effect of particle size on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 0.5 g; pH = Original (9-12).	68
Figure 4.17	Effect of particle size on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 2.0 g; pH = Original (9-12).	69
Figure 4.18	Effect of particle size on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 4.0 g; pH = Original (9-12).	70
Figure 4.19	Effect of particle size on phenol removal efficiency (Initial phenol concentration = 5.0 mg/l; Adsorbent dosage = 7.0 g; pH = Original (9-12).	71
Figure B.1	Langmuir adsorption isotherm of sewage sludge for phenol at $C_o = 0.1$ mg/l; $T = \text{Room } (28 \pm 2 \text{ } ^\circ\text{C})$; pH = Original (9 - 12), Particle size = 63 - 149 μm .	129
Figure B.2	Langmuir adsorption isotherm of sewage sludge for phenol at $C_o = 5.0$ mg/l; $T = \text{Room } (28 \pm 2 \text{ } ^\circ\text{C})$; pH = Original (9 - 12), Particle size = 63 - 149 μm .	129
Figure B.3	Freundlich adsorption isotherm of sewage sludge for phenol at $C_o = 0.1$ mg/l; $T = \text{Room } (28 \pm 2 \text{ } ^\circ\text{C})$; pH = Original (9 - 12), Particle size = 63 - 149 μm .	130
Figure B.4	Freundlich adsorption isotherm of sewage sludge for phenol at $C_o = 5.0$ mg/l; $T = \text{Room } (28 \pm 2 \text{ } ^\circ\text{C})$; pH = Original (9 - 12), Particle size = 63 - 149 μm .	130
Figure B.5	Langmuir adsorption isotherm of sewage sludge for phenol at Adsorbent dosage = 7.0 g; $C_o = 0.1$ mg/l; $T = \text{Room } (28 \pm 2 \text{ } ^\circ\text{C})$; pH = Original (9 - 12); Particle size = 63 - 149 μm .	131
Figure B.6	Langmuir adsorption isotherm of sewage sludge for phenol at Adsorbent dosage = 7.0 g; $C_o = 5.0$ mg/l; $T = \text{Room } (28 \pm 2 \text{ } ^\circ\text{C})$; pH = Original (9 - 12); Particle size = 63 - 149 μm .	131
Figure B.7	Freundlich adsorption isotherm of sewage sludge for phenol at Adsorbent dosage = 7.0 g; $C_o = 0.1$ mg/l; $T = \text{Room } (28 \pm 2 \text{ } ^\circ\text{C})$; pH = Original (9 - 12); Particle size = 63 - 149 μm .	132

Figure B.8	Freundlich adsorption isotherm of sewage sludge for phenol at Adsorbent dosage = 7.0 g; $C_0 = 5.0$ mg/l; T = Room (28 ± 2 °C); pH = Original (9 - 12); Particle size = 63 - 149 μm .	132
Figure B.9	Langmuir adsorption isotherm of sewage sludge for phenol at Contact time = 240 minutes (4 hours) for 0.1 mg/l; T = Room (28 ± 2 °C); pH = Original (9 - 12), Particle size = 63 - 149 μm .	133
Figure B.10	Langmuir adsorption isotherm of sewage sludge for phenol at Contact time = 1200 minutes (20 hours) for 5.0 mg/l; T = Room (28 ± 2 °C); pH = Original (9 - 12), Particle size = 63 - 149 μm .	133
Figure B.11	Freundlich adsorption isotherm of sewage sludge for phenol at Contact time = 240 minutes (4 hours) for 0.1 mg/l; T = Room (28 ± 2 °C); pH = Original (9 - 12), Particle size = 63 - 149 μm .	134
Figure B.12	Freundlich adsorption isotherm of sewage sludge for phenol at Contact time = 1200 minutes (20 hours) for 5.0 mg/l; T = Room (28 ± 2 °C); pH = Original (9 - 12), Particle size = 63 - 149 μm .	134
Figure B.13	Langmuir adsorption isotherm of sewage sludge for phenol at pH 9 - 12 (original) and pH 7 - 8 (normal); T = Room (28 ± 2 °C).	135
Figure B.14	Figure 4.36: Freundlich adsorption isotherm of sewage sludge for phenol at pH 9 - 12 (original) and pH 7 - 8 (normal); T = Room (28 ± 2 °C).	135
Figure B.15	Langmuir adsorption isotherm of sewage sludge for phenol at 63 - 149 μm and 150 - 212 μm ; T = Room (28 ± 2 °C); pH = Original (9 - 12).	136
Figure B.16	Freundlich adsorption isotherm of sewage sludge for phenol at 63 - 149 μm and 150 - 212 μm ; T = Room (28 ± 2 °C); pH = Original (9 - 12).	136
Figure C.1	Electrical oven, Memmert, model ULM400 Schwabach, Germany.	138
Figure C.2	Muffle furnace, CWF 11/5, England.	138
Figure C.3	(a) British Standard Sieve (BS410/1986) (b) Sewage sludge ash was sieved on test sieve shaker for a period of 15 minutes.	139

Figure C.4	Adsorbent was kept inside desiccator.	139
Figure C.5	Analytical balance, Precisa XT220A, Swiss.	140
Figure C.6	Flask shaker, SF1, UK.	140
Figure C.7	pH for mixture was measured using pH-meter, Cyberscan 500, Singapore.	141
Figure C.8	UV spectrophotometer, Genesys™ 2PC, model 336003, USA.	141



PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF SYMBOLS

C_0	Initial phenol concentration (mg/l).
C_e	Phenol concentration in solution at equilibrium (mg/l).
K_d	The equilibrium constant.
K_f	Adsorption capacity (mg/g).
$1/n$	Adsorption intensity.
M_1	Phenol concentration of stock solution (mg/l).
M_2	Phenol concentration to be prepared (mg/l).
q_e	The amount of phenol adsorbed at equilibrium (mg/g).
q_m	The maximum adsorption capacity of adsorbent (mg/g).
V_1	Volume of solution needed to be taken from stock solution (ml).
V_2	Volume of distilled water to be added into diluted volumetric flask until it reached the mark (ml).
ϕ	Diameter.

CHAPTER 1

INTRODUCTION

More than two thousand chemical contaminants have been found in wastewater and about 750 of which have been identified in drinking water. Of these, more than 600 are of organic origin (Singh and Rawat, 1994). Phenols are among the most common water pollutions and it is classified as an organic pollutant. They are used as algicides, bactericides, fungicides, herbicides, insecticides and molluscicides in a variety of industrial, agricultural and domestic fields. Phenols are introduced into surface water from industrial effluents such as those from oil refineries and the coal tar, plastics, leather, paint, dyeing, pharmaceuticals and steels industries as well as from agricultural run off, domestic waste water and chemical spills (Singh and Rawat, 1994).

Phenol has been included in the USEPA list of priority pollutants (Idris and Saed, 2003). Therefore the treatment of them is a necessity. Several physical, chemical and biological processes are used for the removal of phenol from aqueous solutions.

Chemical oxidation, liquid membrane, osmosis, chemical precipitation, filtration, electro dialysis and adsorption are among those methods most commonly employed (Idris and Saed, 2003).

Adsorption is currently being used for the removal of organic and inorganic compounds from aqueous phases and since 1940s, activated carbon has become the water industry's standard for this purpose. Activated carbon is the most widely and effectively used adsorbent. A typical activated carbon particle, whether in a powdered or granular form, has a porous structure consisting of a network of interconnected macropores, mesopores and micropores that provide a good capacity for the adsorption of organic molecules due to its high surface area. However this conventional activated carbon suffers from a number of disadvantages. It is quite expensive and the higher quality is desired the greater the cost would be. Therefore various attempts have been made by researchers to utilize another material to be converted as activated carbon.

In recent years, numerous low cost adsorbent materials have been evaluated for their capacity to remove phenol from aqueous solution. Among adsorbents that have been tested are bentonite (Banat *et. al.*, 2000), rice husk (Munaf *et. al.*, 1997), slash pine bark (Edgehill and Lu, 1998), fly ash generated in the sugar industry (Gupta *et. al.*, 1998), fly ash from the thermal power station (Kumar *et. al.*, 1987; Singh and Rawat, 1994) and local soil (Abuzaid *et. al.*, 2000).

Sewage sludge is being generated in an ever increasing amount due to the rapid urbanization and higher effluent criteria implemented in recent decades. Without proper treatment and disposal, it will cause a secondary pollution problem in the environment. Normally, the conventional disposal options for sewage sludge include landfill, application to farmland and forestry, incineration and sea dumping. Unfortunately, due to competition for landfill space, higher costs and more stringent environmental standards applied, the disposal of sewage sludge is not sustainable anymore. Generally, sewage sludge is carbonaceous in nature and rich in organic matter. Therefore, it has the potential to be used as activated carbon. This replacement could offer the combined benefits of reducing the volume of sludge and producing a valuable adsorbent with lower cost than commercial activated carbons.

In this study the adsorption capacity of sludge generated from sewage treatment plant was examined. The sewage sludge was tested for its adsorption capacity to remove phenol from aqueous solution. The objectives of this study include:-

- i. To evaluate the performance and effectiveness of incinerated sewage sludge in removing phenol by adsorption process.
- ii. To determine the effect of initial phenol concentration, contact time, pH of solution, dosage, and particle size of adsorbent on the adsorption performance.
- iii. To evaluate the applicability of the Langmuir and Freundlich isotherm.

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