

**A STUDY OF SLUDGE PRODUCTION AND COMPOSITION FROM
WATER TREATMENT PLANTS IN PENANG**



**INSTITUT PENYELIDIKAN, PEMBANGUNAN DAN PENGKOMERSILAN
UNIVERSITI TEKNOLOGI MARA
40450 SHAH ALAM, SELANGOR
MALAYSIA**

BY

**NORLILA SHUIB
SALINA HAMEED
MOHD ALI KARIM**

JANUARI 2007

ABSTRACT

A study of sludge based on alum coagulant was carried out at the sedimentation tanks of water treatment plants in Penang which was supervised by Perbadanan Bekalan Air Pulau Pinang Sdn Bhd (PBAPP). Sludge is a settleable solids or dewatered solids and consists of clay, inert materials, microorganisms and chemicals generated from the use of coagulation material. The objectives of the study are to estimate the quantity of sludge produced, to identify the characteristics of raw water and sludge, and to identify the composition of elements in the sludge with the possibility of using it as a useful material in the future. In order to meet these objectives, several tests were conducted on raw water samples and sludges. These include test on pH, turbidity, total suspended solids, moisture content, specific gravity and composition of elements in the sludge. The production of sludge from nine studied treatment plants in Penang was in the range of 5,450.19 kg/d to 1629335.84 kg/d and 5,252.67 kg/d to 1,514266.3 kg/d as observed by using Equation 2.9 and 2.10. Sungai Dua Water Treatment Plant had the highest amount of sludge production and the lowest sludge production was at Bukit Mertajam Water Treatment Plant. The result from this study indicates that raw water quality and weather condition significantly influenced the production of sludge. The study also indicates that the main elements of sludges are silica, aluminum, iron and potassium. The similarity of these substances with other construction materials will enable the possibility of sludge to be used as a construction material in the future.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	i
ABSTRACT	ii
TABLE OF CONTENTS	iii
LIST OF TABLES	vii
LIST OF FIGURES	ix
LIST OF SYMBOLS	xi
CHAPTER 1: INTRODUCTION	
1.1 Introduction	1
1.2 Water Supply and Waste Disposal in Malaysia	3
1.3 Background of Study	4
1.4 Case Study Background	6
1.5 Objectives of the Study	9
1.6 Scope of Study	9
1.7 Significant of Study	10
1.8 Chapter Arrangement in Report	10
CHAPTER 2: LITERATURE REVIEW	
2.1 Introduction	12
2.2 Definition of Sludge	13
2.3 Water Treatment Waste	14
2.3.1 Water Treatment Process and its Waste	14
2.3.2 Water Treatment Sludge	18

2.4	Type of Water Treatment Sludge	18
2.4.1	Filter Backwash Water Sludge	18
2.4.2	Coagulant Sludge	19
2.4.3	Iron and Manganese Softening Precipitates	20
2.4.4	Softening Sludge	20
2.5	Characteristics of Water Treatment Sludge	21
2.5.1	Physical Characteristic	21
2.5.2	Chemical Characteristic	29
2.5.3	Biological Characteristic	32
2.6	Quantity of Coagulant Sludge	32
2.6.1	Introduction	32
2.6.2	Calculation for Quantity of Alum Sludge	34
2.7	Sludge and Applications Study	35
2.7.1	Land Application	36
2.7.2	Recycling Sludge in Manufacturing Processes	39
2.8	Laboratory Experiment for Raw Water and Sludge	43
2.8.1	Physical Analysis	43
2.8.1.1	Turbidity	43
2.8.1.2	Total suspended solids	45
2.8.1.3	Moisture content	45
2.8.1.4	Specific gravity	46
2.8.2	Chemical Analysis	47
2.8.2.1	X – Ray fluorescence / XRF analysis	47
2.8.2.2	X – Ray Diffraction / XRD analysis	48
2.8.2.3	Atomic Absorption Spectrophotometer / AAS & Flame Emission / FE and Spectrophotometer DR 2000	48
2.8.3	Microstructure Examination	53
2.8.3.1	Scanning electron microscopic / SEM analysis	53
2.8.3.2	Electron diffraction X – Ray / EDX	54

CHAPTER 3: METHODOLOGY

3.1	Introduction	55
-----	--------------	----

3.2	Research Methodology	56
3.2.1	Determining Study Locations and Choose the Significant Treatment Water Plants	57
3.2.2	Estimating the Sludge Production	57
3.2.3	Sampling and Sample Preparation	58
3.2.3.1	Raw water	58
3.2.3.2	Sludge	59
3.2.4	Raw Water and Sludge Experiment	64
3.2.4.1	Turbidity test	64
3.2.4.2	pH test	65
3.2.4.3	Total suspended solid procedures	66
3.2.4.4	Moisture content measurement test	71
3.2.4.5	Specific gravity test	72
3.2.4.6	X-Ray Diffraction analysis	74
3.2.4.7	Scanning Electron Microscopic (SEM) and Quantitative EDX test	75
3.2.4.8	Atoms Absorption Spectrophotometer (AAS) and Finite Element (FE)	76
3.2.4.9	Testing sample with Spectrophotometer DR 2000	79

CHAPTER 4: RESULTS AND DISCUSSION

4.1	Introduction	81
4.2	Characteristics of Raw Water	81
4.2.1	Turbidity	82
4.2.2	Total Suspended Solid	85
4.2.3	Relationship Between Turbidity and Total Suspended Solid	88
4.2.4	Raw Water Flow Rate	89
4.2.5	Alum Dosage	90
4.2.6	pH Value of Raw Water	92
4.3	Quantity of Sludge	92
4.4	Characteristics of Sludge	94
4.4.1	Moisture Content	94

4.4.2	Bulk Density	95
4.4.3	Specific Gravity	97
4.5	Chemical Analysis and Microstructure of Sludge	98
4.5.1	X-Ray Diffraction Test (XRD)	98
4.5.2	X-Ray Fluorescence Test (XRF)	100
4.5.3	Semi-quantitative Test (EDX) or Electron Dispersion X-Ray Test	102
4.5.4	Atomic Absorb Spectrometer Test (AAS) and flame emission (FE)	103
4.5.5	DR 2000 Spectrophotometer Test	104
4.5.6	Comparison of results from XRF, EDX, AAS and DR 2000 testings	104
4.5.7	Comparison of results from XRF, EDX, AAS and DR 2000 testings and chemical composition of sludge and various materials	108
4.5.8	Scanning Electron Microscope Analysis (SEM)	110

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1	Conclusion	112
5.2	Recommendation	114

REFERENCES

APPENDICES