UNIVERSITI TEKNOLOGI MARA

PERFORMANCE OF SEWAGE PUMP STATIONS WITH GRIT CHAMBERS FOR SEDIMENT CONTROL IN MALAYSIA

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ABSTRACT

Sewage pump stations in tropical regions are frequently affected by rainfall-driven sediment surges, which can increase grit accumulation, hydraulic head losses, and pump instability. However, the field performance of grit chambers (GCs) in reducing these impacts remains insufficiently quantified. This study evaluated two sewage pump stations in Kajang, Malaysia: PS-1, equipped with a horizontal-flow GC and mechanical grit handling system, and PS-2, operated without upstream grit removal. The objective was to compare sediment-control efficiency and hydraulic stability between stations with and without GC protection under tropical wet-weather conditions. Both stations were monitored over 100 days from 24 July to 31 October 2023. High-resolution time-series data on rainfall, flow rate (Q), total suspended solids (TSS), volatile suspended solids (VSS), and pressure head (h) were collected and analysed using Principal Component Analysis (PCA), Agglomerative Hierarchical Clustering (AHC), the Kruskal–Wallis H-test, Sensitivity Analysis (SA), and Artificial Neural Network (ANN) modelling. PCA showed that rainfall intensity and antecedent dry periods explained 77.83% of the variance in TSS dynamics, confirming a strong rainfall–sediment relationship. The AHC-derived rainfall classes were then used to group wet-weather datasets before comparing station performance. PS-1 consistently achieved positive TSS removal across all rainfall classes, whereas PS-2 recorded negative removal under moderate–heavy and high-intensity rainfall, indicating sediment resuspension under hydraulic stress. The Kruskal–Wallis H-test confirmed significant differences in solids-removal efficiency between the two stations ($K = 193.098$, $p < 0.0001$). SA and ANN results further showed that PS-1 had lower hydraulic sensitivity and more accurate pressure-head prediction than PS-2. Overall, the findings demonstrate that GC installation can reduce sediment-induced head losses, improve pump reliability, and sustain hydraulic performance. These results support strengthening MSIG/SPAN guidance through upstream grit removal requirements and quantitative performance benchmarks for tropical sewerage networks.

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TABLE OF CONTENTS

		Page
CONFIRMATION BY PANEL OF EXAMINERS		**ii**
AUTHOR'S DECLARATION		**iii**
ABSTRACT		**iv**
ACKNOWLEDGEMENT		**v**
TABLE OF CONTENTS		**vi**
LIST OF TABLES		**x**
LIST OF FIGURES		**xii**
LIST OF PLATES		**xv**
LIST OF SYMBOLS		**xvi**
LIST OF ABBREVIATIONS		**xviii**
CHAPTER 1	**INTRODUCTION**	**1**
1.1	Research Background	1
1.2	Research Problem	4
1.3	Research Gap	5
1.4	Research Objectives	6
1.5	Research Questions	7
1.6	Significance of the Study	8
1.7	Scope of the Study and Limitations	9
1.7.1	Scope of the Study	9
1.7.2	Exclusions of the Study	10
1.7.3	Limitations of the Study	11
1.8	Structure of the Thesis	13
CHAPTER 2	**LITERATURE REVIEW**	**15**
2.1	Introduction	15
2.2	Sewage Pump Stations and Grit Chambers	16
2.2.1	Engineering Roles and Challenges of Sewage Pump Stations	16
2.2.2	Malaysian Implementation and Operational Realities	18

CHAPTER 1
INTRODUCTION

1.1 Research Background

Urban sewerage infrastructure is a fundamental pillar of sustainable city development, encompassing interconnected systems such as sewer networks, sewage pump stations (PSs), sewage treatment plants (STPs), and sludge treatment facilities. Within this chain, sewage PSs function as critical hydraulic nodes that transfer wastewater from low-lying catchments to downstream treatment via pressurised conveyance. When PS performance deteriorates, the consequences are system-wide: increased maintenance downtime, higher energy demand, premature equipment wear, and elevated risk of service disruptions. In practice, one of the most persistent drivers of PS performance degradation is sediment (grit) accumulation and resuspension, which progressively reduces wet-well capacity, induces abrasive wear on pumps and valves, and destabilises hydraulic behaviour (MSIG Vol III, 2009).

At the global and regional scale, this sediment problem is increasingly shaped by climate variability and rapid urbanisation, which intensify wet-weather inflows and mobilise deposits from upstream sewer networks. In Malaysia, flood-related disturbances have become more frequent and impactful, consistent with evidence that climate change and urban development pressures increase exposure and loss severity (Ahmad et al., 2025; Rosmadi et al., 2023). Recent national reporting reinforces the continuing magnitude of flood impacts: the Department of Statistics Malaysia (DOSM) estimated RM933.4 million in flood-related losses for Malaysia in 2024 (DOSM, 2025), highlighting the significant burden on public infrastructure and essential services. In addition, DOSM's environment statistics show that floods remain the predominant disaster type, accounting for 218 cases (95.6%) of recorded disaster events (reported in the latest environment statistics release), underscoring the dominance of flood-driven disruptions in Malaysia's risk landscape. These conditions are operationally important for sewerage systems because high-intensity rainfall events can trigger rapid inflow surges and transport sediment and suspended solids into chambers, wet wells, and pumping pipelines.