DEVELOPMENT OF CRIETRIA FOR FORMING AND MAINTAINNING A SLUDGE BLANKET IN AN UPFLOW SLUDGE BLANKET CLARIFIER/ PULSATOR

I.M.W.K. Illangasinghe

(118068L)

Degree of Doctor of Philosophy

Department of Civil Engineering

University of Moratuwa
Sri Lanka

July 2019

DEVELOPMENT OF CRIETRIA FOR FORMING AND MAINTAINNING A SLUDGE BLANKET IN AN UPFLOW SLUDGE BLANKET CLARIFIER/ PULSATOR

I.M.W.K. Illangasinghe

(118068L)

Thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Department of Civil Engineering

University of Moratuwa
Sri Lanka

July 2019

Declaration

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to the University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

I.M.W.K. Illangasinghe Date:

The above candidate has carried out research for the Ph.D. thesis under our supervision.

Research Supervisors

Professor (Mrs.) Niranjanie Ratnayake Date: ………………..

Professor Jagath Manatunge Date: ………………..

Abstract
Forming and maintaining a sludge (floc) blanket

Keywords: Clarifier, floc blanket, particle structuring, sludge cohesion coefficient, settling velocity

Coagulation and flocculation is attained within a sludge (floc) blanket of an upward flow clarifier unit. In this study cohesivity of the floc blanket, measured by the indicator sludge cohesion coefficient (*SCC*) is used to explain the blanket characteristics and response of the blanket to variations of raw water turbidity (RWT), coagulant dose and ambient conditions.
The study found that *SCC* is an appropriate parameter to monitor floc blanket characteristics. A satisfactory floc blanket is established when *SCC* varies within 0.3 – 1.3 mm/sec and the sludge volume fraction of the blanket is between 0.2 and 0.25. At RWT occurrences > 450 NTU, the blanket cohesivity reduces. Increased coagulant dose leads to restabilization of particles by charge reversal leading to reduction of blanket cohesivity. It is recommended to introduce preliminary sedimentation (prior to clarifier) to effectively treat high turbidity raw water.
Beyond RWT 300 NTU optimum coagulant dose reported from *SCC* test is lower than that of Jar test. This will give savings in coagulants in the range of 6 - 25%. When RWT is > 300 NTU, the linear relationship established using the two parameters during the study can be used to find the optimum dose after carrying Jar test.
The study found that high inflow temperature reduces blanket cohesivity and particle settling efficiency. There is a significant linear relationship between the influent temperature and the effluent quality.
The particle structuring within the blanket is due to hydrodynamic forces between the particles counterbalanced by the cohesive forces. A steady floc blanket is formed when the individual particles are agglomerated and clusters are formed. Cluster formation/destruction is due to the cohesive/inertial forces between particles and/or particle clusters. With low *Re* (< 1) cohesive forces govern. Interstitial spaces between particles vary due to cluster formation/destruction, leading to the increase/decrease of blanket settling velocity.

Acknowledgement

I would like to express my deepest appreciation to all those who provided support enabling me to complete this doctoral thesis.

First, I would like to express my sincere gratitude to my supervisors Professor (Mrs.) Niranjanie Ratnayake, Professor Jagath Manatunge, and progress review chairman Dr. (Mrs.) Niranjalie Jayasuriya for the continuous support during my doctoral studies. Their guidance, motivation and immense knowledge helped me all the time of research, publication, and writing of this thesis.

My sincere thanks also go to Ms. Anuradha Disanayake, Ms. Shasikala Jayathilaka and all other laboratory staff who provided immense support during the laboratory research work. Without their timely support, it would not have been possible to carry out the experiments of this research.

I appreciate the continuing support given by Mr. Asanka Jayasinghe by type setting this document as well as all other documentation work during my study period.

I have to appreciate the guidance given by the Progress Review Committee for their valuable comment and advice, which were invaluable in the advancement of this research.

Furthermore, I would also like to acknowledge the National Water Supply and Drainage Board for allowing me to use of Kandy South Treatment Plant and the laboratory facilities for my research studies.

Last but not the least, I would like to thank my family and friends for supporting me spiritually throughout the study period.

TABLE OF CONTENT

List of Figures

List of Tables

List of Abbreviations

Al	- Aluminum
V	- Apparent Volume
Vs	- Blanket Settling (Sedimentation) Velocity
R^2	- Coefficient of Determination
ρ	- Density of Fluid
D	- Drafting
μ	- Dynamic Viscosity
EFT	- Effluent Turbidity
m	- Empirical Exponent
Fe	- Ferric
KMC	- Kandy Municipal Council
K	- Kissing
G	-Mixing Intensity (Shear Rate)
NWS & DB	- National Water Supply & Drainage Board
NTU	- Nephelometric Turbidity Units
C	- Particle Concentration
d	- Particle Diameter
r	- Pearson Correlation Coefficient
PACL	- Poly Aluminum Chloride
pH	- Potential of Hydrogen
RWT	- Raw Water Turbidity
rpm	- Revolutions Per Minute
Re	- Reynolds Number
∞	- Significance Level
h_1	- Sludge/Clear
SCC (K)	- Sludge Cohesion Coefficient
SCT	- Sludge Cohesion Test
h	- Sludge Height
SV (SVF)	- Sludge Volume Fraction
SVT	- Sludge Volume Test
Us	- Superficial Velocity
Vt	- Terminal Settling Velocity
t	- Time
T	- Tumbling
u	- Upward Velocity
Φ	- Void age
Vo	- Volume at Zero Velocity