DEVELOPMENT OF WALL PUTTY FOR TROPICS USING DRINKING WATER TREATMENT PLANT WASTE ALUM SLUDGE

Galkanda Arachchige Himahansi Hasinthara Galkanda

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Degree of Doctor of Philosophy in Civil Engineering

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DECLARATION OF CANDIDATE AND SUPERVISOR

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ABSTRACT

Water is the main source of life; therefore, a sufficient amount of safe water consumption is essential for public health. It is one of the responsibilities of a country, to ensure the access of its citizens to consume sufficient safe water. In Sri Lanka, the national water supply and drainage board (NWSDB) is the responsible authority for drinking water purification and distribution. NWSDB owned 323 water supply schemes. In drinking water treatment plants, surface water is collected and treated to drinking quality removing impurities dissolved in surface water. In the purification process aluminium sulphate ($Al_2(SO_4)_3$) (Alum) is used as the coagulant and generated alum sludge at the end. The sludge disposal to surface water bodies creates the undesirable formation of mud deposits according to the activation of alum. Direct discharge of sludge into water bodies creates damage to its' creatures and ecosystems. Therefore, direct disposal of alum sludge in open lands and water bodies is prohibited by legislation. Dewatered alum sludge is disposed at landfills and rock blasting wells. However, the increasing daily generation of sludge is creating an urgent necessity for a sustainable solution. The increasing amount of daily alum sludge production has considerable environmental and economic concerns in most countries. Therefore, the world's attention turned to finding a sustainable way to reuse or recycle DWTP alum sludge. This research aimed to address the issues mentioned, by developing a wall putty using waste alum sludge generated in drinking water treatment plants (DWTP) in Sri Lanka. Properties of the DWTP waste sludge differ according to the climatic conditions, geographical conditions, water treatment process and raw water quality. The research was conducted after the identification of the properties of DWTP waste alum sludge of different plants. Laboratory experiments were conducted to study the properties of sludge samples collected from DWTPs in Ambathale, Biyagama and Kandana. Biyagama DWTP was selected to collect sludge for the study due to the low moisture content and high solid content compared to other samples. Waste sludge is discharged at the end of the water treatment process, in semisolid form with high moisture content and it is dewatered through a sludge treatment process in Biyagama DWTP. Dewatered sludge generation of the plant is estimated at $10m^3$ per day. Properties of DWTP waste alum sludge were studied. According to the results, moisture content variation, volumetric shrinkage variation, chemical composition and heavy metal analysis of the sludge was analyzed. In the first phase of the study, experiments were conducted to develop a wall putty mix using wet alum sludge. Test results reveal that volumetric shrinkage can be reduced with physical additives and adhesiveness can be improved with binders, but a wall putty mix cannot be developed with wet sludge by mixing additives and a binder, due to the high moisture content, high shrinkage and alum activation. In the second phase of the study, experiments were conducted to develop a dry powder from wet sludge overcoming the alum activation. To that thermal alterations of DWTP waste alum sludge were studied. Colour and density variations of the burned sludge at different temperatures were studied. Sludge becomes harder when burned, due to the alum activation and none of the processes that exist in the world, to produce dry powder from DWTP alum sludge. Alum activation of the sludge can be overcome by burning sludge with a lubricant. According to the experiments, coconut oil is identified as an effective lubricant. The density of burned sludge with oil is lower than that of burned sludge without oil at each temperature. Finally, a process was developed to produce dry powder from DWTP alum sludge. In the final phase of the study putty properties of the developed dry powder were analyzed and optimized and the performances of the developed wall putty mix were analyzed compared to existing wall finishes. And the real scale performances of the putty were tested. Finally, it was concluded that the developed dry powder is applicable as a wall finisher successfully on both interior and exterior walls. And also new research areas were identified for further studies from this research.

***Keywords**: Alum sludge, Drinking water treatment plant, Sludge putty, Tropical climate*

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LIST OF ABBREVIATIONS

Abbreviation	Description
DWTP	Drinking Water Treatment Plant
NWSDB	National Water Supply and Drainage Board
SOF	Scaled Off Factor
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence