

# **STUDY OF LEACHING CHARACTERISTICS OF STAINLESS STEEL PICKLING SLUDGE & ITS UTILIZATION WITH CONCRETE USING TAGUCHI METHODOLOGY**

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

**Master of Technology**

in

**Environmental Engineering**

by

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**CERTIFICATE**

This is to certify that **Sakshi Garg (2K12/ENE/11)** has submitted the thesis titled "**Study of leaching characteristics of stainless steel pickling sludge & its utilization with concrete using Taguchi methodology**" to the Department of Environmental Engineering, Delhi Technological University, is a bonafide research carried out by her under our guidance and supervision. The matter contained in the thesis has not been submitted to any other University or Institution for the award of degree or diploma.

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*Dedicated*  
*To*  
*My Parents, My brother*  
*&*  
*Environment*

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## Abstract

Steel finishing operations such as pickling, galvanizing, plating, etc., involve a process of removing scale, rust and dust from the surface of stainless steel. In this, sheets of steel are immersed in hot acidic solution resulting in waste liquor which contains heavy metals like Fe, Cr, Ni, etc. When treated with lime, these heavy metals get settled as metal hydroxides in form of sludge. As per the Act of Hazardous Waste (Management and Handling) Rules, 1989, the disposal of lime treated spent pickling sludge should be done with consideration and is not easy. In normal practice, this sludge is being stored in leak proof bags and no proper disposal technique is being employed by small and medium industries.

An attempt has therefore been made to utilize the lime treated pickling sludge in cement concrete mix in the presence of fly-ash as a binder agent. The main objective is to immobilize heavy metals in the concrete matrix and studying its leaching characteristics and compressive strength. Sludge is characterized for the heavy metal content using AAS, EDX and XRD. Other physical and chemical properties are also analysed. Test cubes of nominal mix M20 were prepared and these were tested for its 7 and 28 days compressive strength. Toxicity characteristics leaching procedure (TCLP) test as per USEPA was carried out on these cubes to study the extent of immobilization and stabilization of heavy metals in the concrete matrix.

For this, Four factors were varied on three levels i.e. Percentage of cement replaced by sludge (5%, 7.5% & 10%) and Percentage of fly-ash (0%, 15% & 20%), type of cement used and particle size grading of sludge, to assess the effect of these factors on compressive strength and heavy metal concentrations in leachate. Taguchi methodology (L9 orthogonal array) was used for optimizing the design of experiments and for further analysis.

Experimental results show that the lime treated pickling sludge can be utilized with cement/concrete with some binding materials like fly-ash. By Analysis of Mean (ANOM) method, it was found that 7.5% addition of sludge and 20% fly-ash as partial replacement of cement with 43 grade OPC and sludge particle size ranging between 0.3 to 2.36mm produced the optimal performance for compressive strength and heavy metal immobilization values of the cement-sludge-flyash concrete cubes. By Analysis of Variance (ANOVA) method, it was found that particle size grading of sludge and percent of sludge added as cement replacement contributed 46% and 41% respectively to the optimal performance. Formation of  $C_2H$ ,  $C_3H$  and gypsum (C-S-H gel) may be contributing in the better performance of concrete.

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## LIST OF ACRONYMS

<b>AAS</b>	Atomic Absorption Spectroscopy
<b>ANOM</b>	Analysis of Mean
<b>ANOVA</b>	Analysis of variance
<b>APHA</b>	American Public Health Association
<b>BIS</b>	Bureau of Indian Standards
<b>CPCB</b>	Central Pollution Control Board
<b>C2S</b>	Di Calcium Silicates
<b>C3S</b>	Tri Calcium Silicates
<b>DOE</b>	Design of Experiments
<b>DPCC</b>	Delhi Pollution Control Committee
<b>EDX</b>	Energy Dispersive X-Ray spectroscopy
<b>ETP</b>	Effluent Treatment Plant
<b>HW</b>	Hazardous Waste
<b>LOI</b>	Loss on Ignition
<b>MT</b>	Million Ton
<b>S/N</b>	Sound/ Noise
<b>S/S</b>	Solidification/ Stabilization
<b>SEM</b>	Scanning Emission Microscope
<b>SS</b>	Stainless Steel
<b>TCLP</b>	Toxicity Characteristic Leaching Procedure
<b>TPA</b>	Tons per Annum
<b>USEPA</b>	United states Environment Protection agency
<b>XRD:</b>	X- Ray Diffractometer
<b>µm</b>	Micro meters