COMPARATIVE STUDY OF SOLIDIFICATION AND STABILIZATION OF HAZARDOUS WASTE FROM TANNERY INDUSTRY

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Abstract: This research work, treatment of sludge which is obtained from tannery industries. The sludge consists of potentially toxic heavy metals and organisms, was analyzed, and the performance of solidification and stabilization (S/S) of the sludge was discussed. The toxic characteristics of the sludge were determined by means of extraction procedure toxicity test the standards specify by EPEPA 1311 & 200.8 S/S investigation were conducted using fly ash alone and fly ash with Portland cement to solidify the sludge containing high concentration to total organic subtances Cr, Pb, Cu, Zn, Ni, Fe and Cl. The waste binder ratios of 72 sludge specimens were kept below 0/100 and 30 / 100, in both fly ash and fly ash with OPC. Each the specimens were cured at room temperature for 3,7,14 and 28 days. The compressive strength of these two sets of specimens were determined also the feasibility of using the solidified. Tannery sludge in to safe landfill. The compressive strength values indicate the dilution of sludge mass in to rainwater. The heavy metal were identified which were lower than the standard concentration in EPA and RCRA (Recourse, conservation & recovery acts) recommendations.

Keywords: **Solidification / stabilization, hazardous waste treatment – compressive strength – fly ash – Portland cement – leaching.**

1. INTRODUCTION:

Solidification/ stabilization (S/S) is widely used process to treat the hazardous wastes. (S.Bayar et al 2013 cioffi et al 2002). This technology potentially useful for reducing physical and chemical properties of hazardous waste. This process is a cost effective methods. The end product of the project with safety environmental impact as per USEPA (2002). Stabilization means to minimize the toxic behavior of the waste by the means chemical reactions. Solidification means to produce a monolithic solid with a structural behavior (conner UR et.al). If there is no exact laboratory test procedure to determine the stabilization efficiency for the sludge. The solidification and stabilization is evaluated by the following ways 1. Leaching behavior, 2. Permeability and structural behavior. So many physical and chemical evaluation procedures, have been available, the very general physical tests are compressive strength and permeability. In the chemical analysis the leaching test is used to identify the leaching behavior or solidified sludge the leaching test have to the be conducted regularly (singn TS et al 2006).

At present the literature concentrating the application of cement based S/S for industrial sludge has develop into toxic waste management. Lot of investigation has been made the leaching of metals during S/S. All the studies were conducted by preparing concrete sample in the lab. The main also of this study were to the S/S technology on the treatment of tannery sludge, and to analysis the feasibility for safe disposal. The investigation has been divided in to two phase. In the first phase. The tannery sludge analysis is with fly ash, and in the second phase the sludge with OPC and fly ash. In the both the phases, the stabilization characteristics of the sludge were evaluated from TCLP tests, after the each S/S process the water/binder (W/B) ratios were also determined according to compressive strength of the solidified materials, satisfactory performance were obtained in the study.

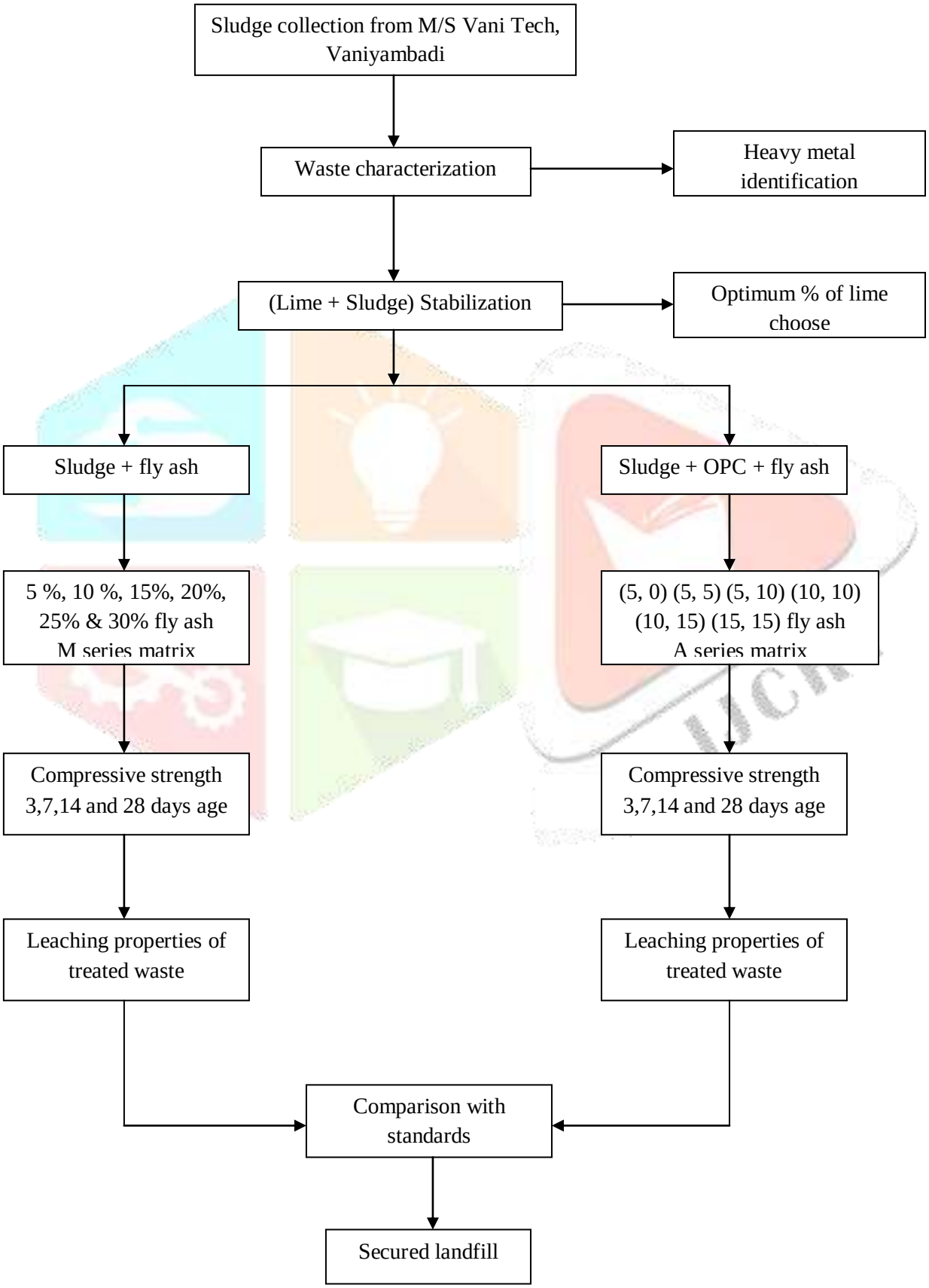
2. MATERIALS AND METHODS

In this research work, the S/S process has been applied to the tannery industry waste. The raw sludge samples from tannery industry were considered in the study M/S Vani Tech Limited, Vaniyambadi, Vellore district, Tamilnadu. The raw sludge samples collected with assistance of the CETP authority.

The sludge was analyzed by means of the TCLP test for both sludge with fly ash mixed matrix (M series) and OPC + fly ash mixed matrix (A series) and the test results compared with standard specified by ESEPA 1311 & 2008. Before the S/S process the lime is added to the raw sludge for the purpose of stabilization and also killing the micro organism present in the sludge. The optimum quantity of lime which is suitable for the stabilization process is calculated by adding of lime 10 %, 20 %, 30 %, 40 % and 50 % by total weight. The selection of optimum quantity of lime which is added in to the sludge, the minimum lime attain the maximum stabilization of hazardous waste. In our study we choice 30 % of lime is added to the sludge for stabilization. In this investigation we analyze the physical and chemical properties such as moisture content, volatile solids, Mn, Cd, Pb, Zn, Fe, Ni, Cu, Cl and Cr. (Jayasankar.R et,al .international conference on 'RTESE'17 ,2017)

After the characterization of lime mixed sludge, the fly ash, in this analysis we concentrated the variations in the basic properties of the solidified fly ash with lime mixed sludge. Also to elevated the results of the lime stabilized sludge and fly ash properties also determine the compressive strength wit minimum standards of hazardous waste management HAZWAMS – 2010 – 11 (Jayasankar . R. et al .IJSRR .vol.7.No.1.2018)

The compressive strength tests and leaching tests methodology were conducted to the perform the S/S efficiency for solidified materials as shown in fig. 1



3.Characterization of hazardous work:

The sludge sample was collected before the dewatering process. AoAc 940.08:2005 method the amount of Mn, Cd, Pb, Zn, Fe, Ni, Cu, Cr present in sludge has been determined. The moisture content has determined as per IS 2720 (part2)1973. Volatile solids determined as per APHA 2540G methods. The compressive strength of has determined by HAZWAMS 2010 – 2011 RCRA act. The composition of raw waste and lime mixed waste determined by these process and the leaching concentration of treated sewage is tabulated. The compressive strength and leaching concentration were compared to six different regulations to decide whether the samples could be experimentally determined as hazardous waste. Maximum concentration of metals (Mn, Cd, Pb, Zn, Fe, Ni, Cu and Cr) for characteristic EP toxicity is given in table 2. As in the sludge plus fly as mix matrix M series cubes Pb, Zn, Fe, Ni, Cu, Cr concentrations, of this cubes were all above their standards, but in the sludge + fly ash + OPC, a series cubes satisfy the EPA regulations. TOC concentrations measured by extraction procedure (EP) toxicity test method EPA 1311 (TCLP).

As results, waste in sludge from tannery industry was determined to be hazardous but after the S/S treatment the sludge + fly ash + OPC mixed sludge is suitable for safe landfill.

4.S/S and Evaluation test:

Fly ash is the inorganic residue of lignite or coal obtained after combustion in boilers. It mainly consists of silica, alumina, and calcium oxide etc., Portland cement as a binder. Fly ash, Portland cement was mixed with the sludge to solidify the waste and immobilize the pollutants control and other specimens were prepared with dried sludge. In the first phase, sludge with fly ash (M) ,in the second phase sludge with OPC and fly ash. Six plus six different mixing ratios of waste binder (W/B) were changed from 0/100 and 3/100 process contained until concrete had a uniform appearance. Specimens were mixed manually, initially and after the procedure were repeated by mixers. Water / cement ratio of their specimens for each mixtures were kept 0.40 to 0.50 cube specimen dimensions of 7.5 x 7.5 x 7.5 cm were moulded and cured in room temperature at 4 different curing time.

The moulded specimens were examined for the change in compressive strength at the end of 3, 7, 14 and 28 days curing time by compression test. The compliance test used for heavy metal leaching was EP toxicity test (EPA 1311 TCLP) which was performed by sludge specimen was crushed to pass a 9.5 mm sieve. The crushed sample is analyzed by the above procedure.

5. Result and discussion:

Mechanical properties:

The compressive strength of M series mix (Sludge + fly ash) was measured 3, 7, 14 and 28 days curing periods. The compressive strength values were compared to an average compressive strength.

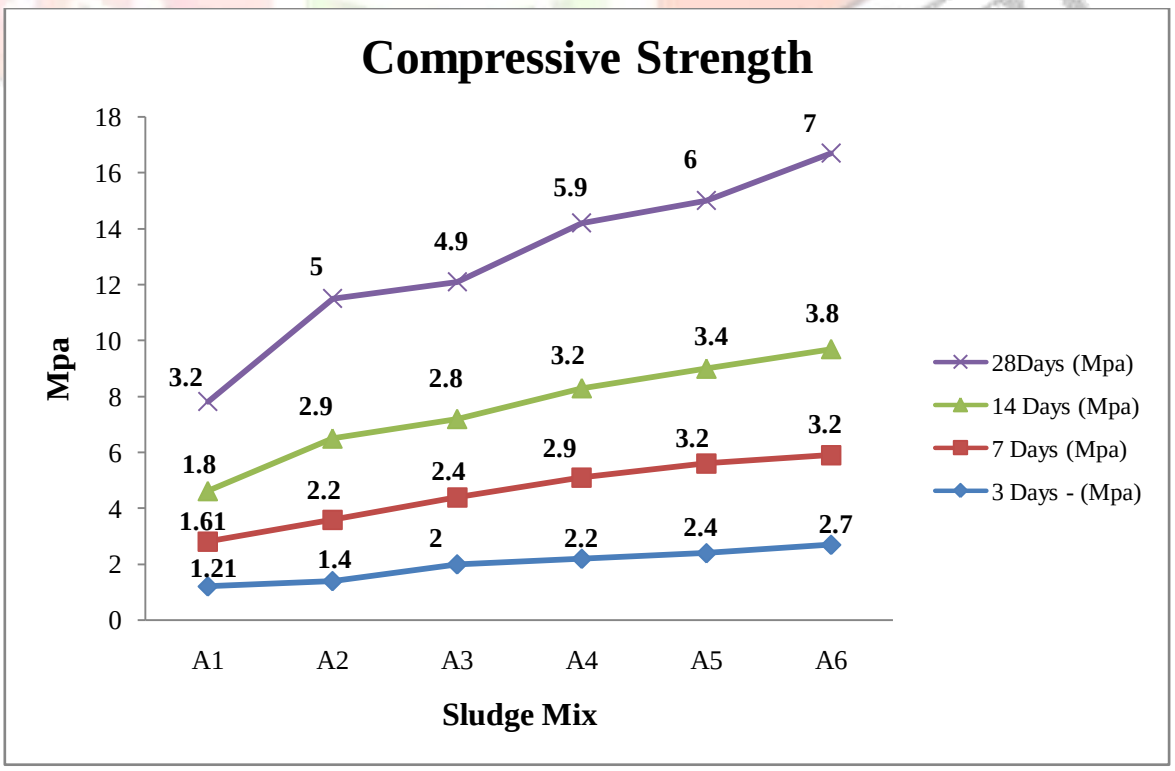


Fig – 2 Compressive strength as a function of W/B for different curing times (Sludge + OPC+ Fly ash)

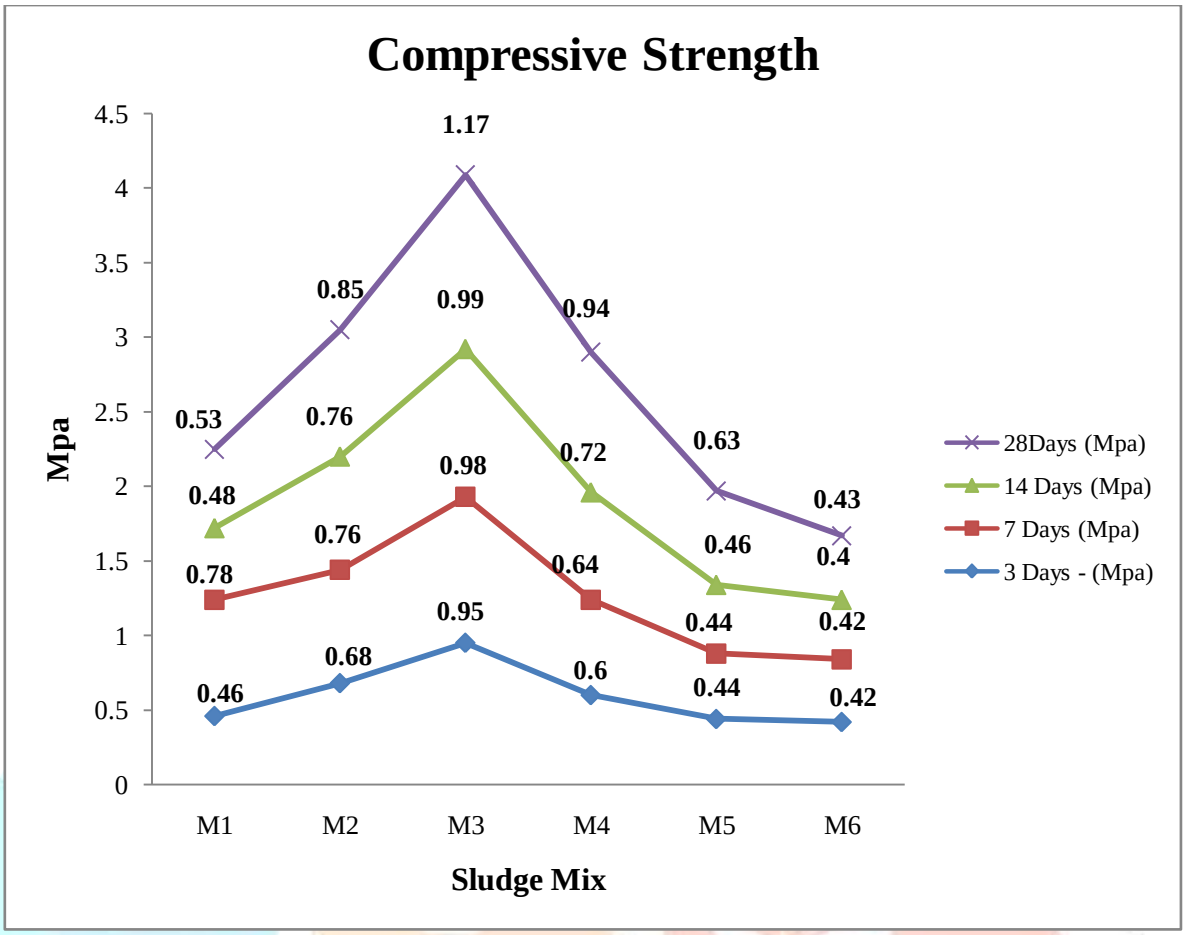
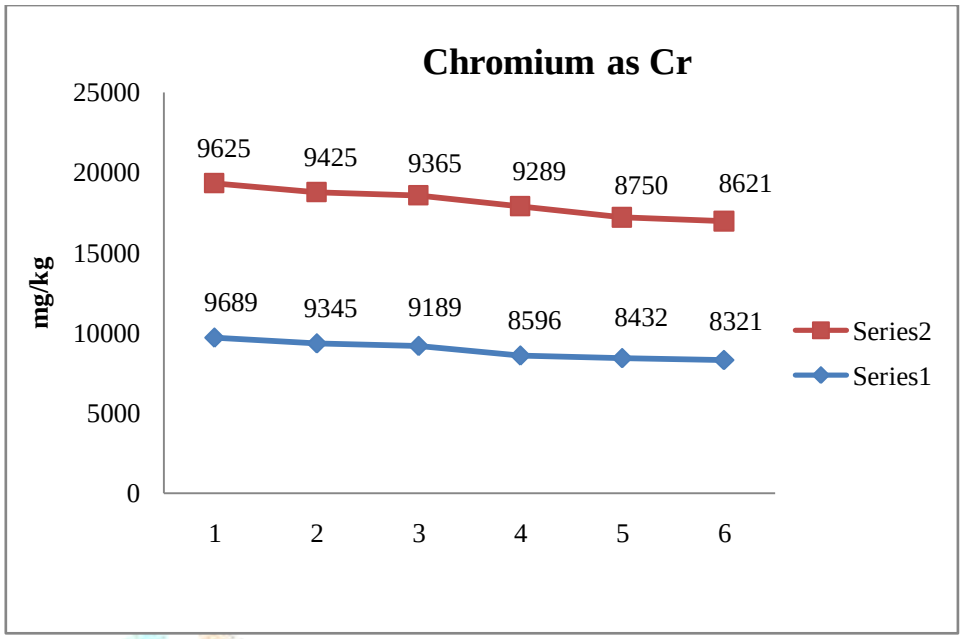


Fig – 3 Compressive strength as a function of W/B for different curing times (Sludge + Fly ash)

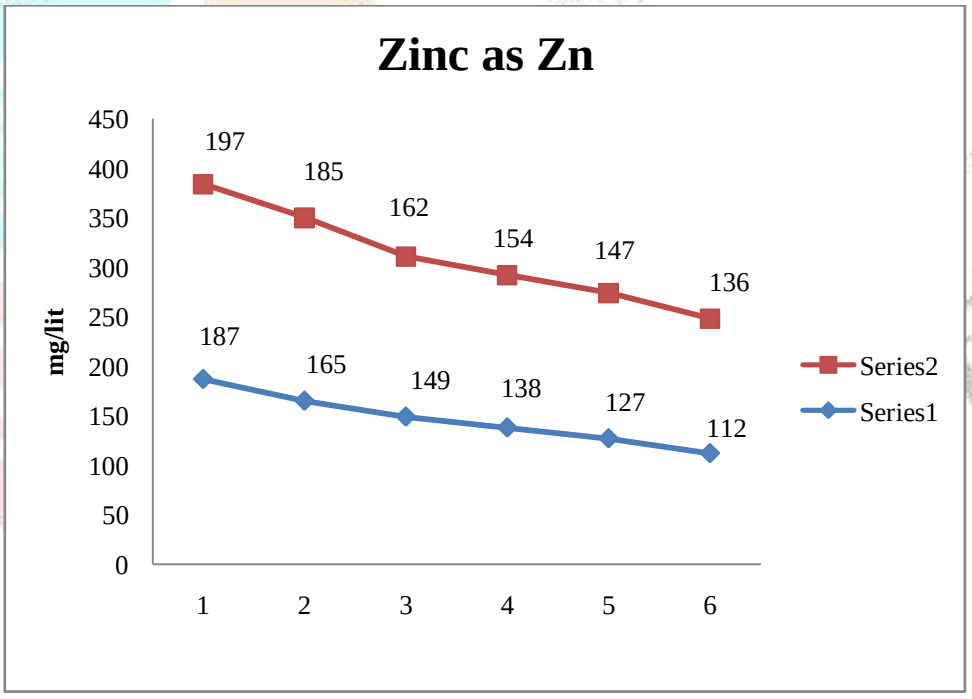
It was shown that the higher W/B ratio, the lower the compressive strength for this solidified sludge. Maximum and minimum compressive strengths (1.21 to 7 N/mm^2) for sludge + fly ash + OPC mix and 0.46 to 1.17 N / mm^2 for sludge + fly as mix figure 2 shows the change of compressive strength as a function of W/B ratios for different curing periods. There were a little difference between the compressive strength values for 21 and 28 days. Better performance of S/S of treated sludge for 28 days curing was observed high compressive strength for tannery sludge (7 N/mm^2) showed in the sludge + fly ash + OPC could be used for safe landfill.

6. Leaching properties:

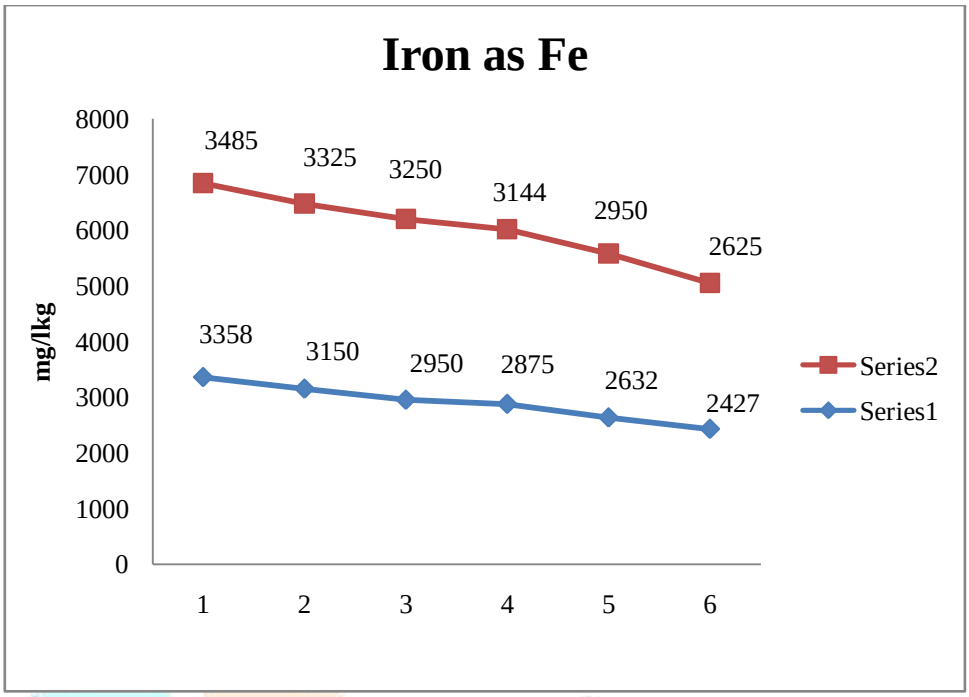
Leaching tests were done for sludge specimens, heavy metal concentrations in leachates of specimens are shown in table 1. The total concentration of heavy metals in raw waste are very high, they were zero or less than minimal detectable limits in leachates for most of the leached specimens. The leaching test results by EPA 1311 TCPL showed that heavy metal leaching from the specimens were lower.



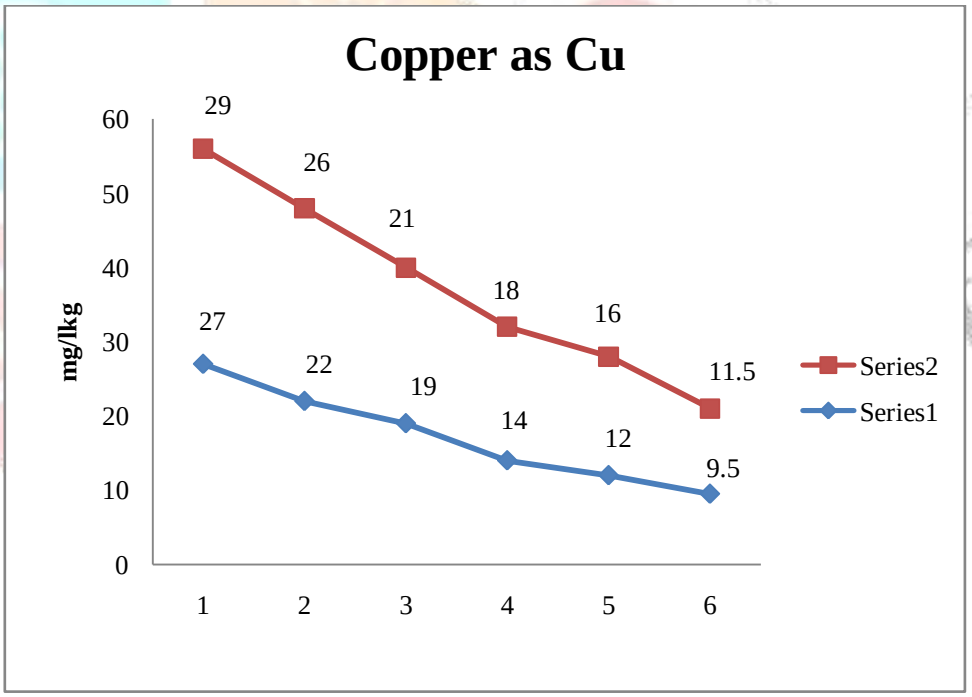
Chromium (Cr)



Zinc (Zn)

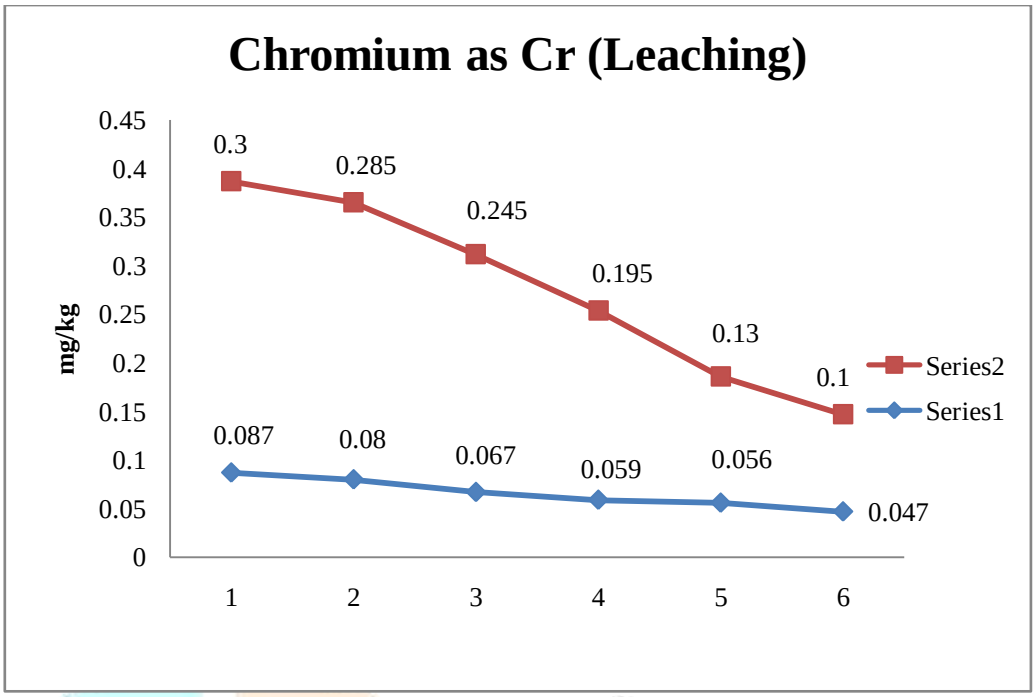


Iron (Fe)

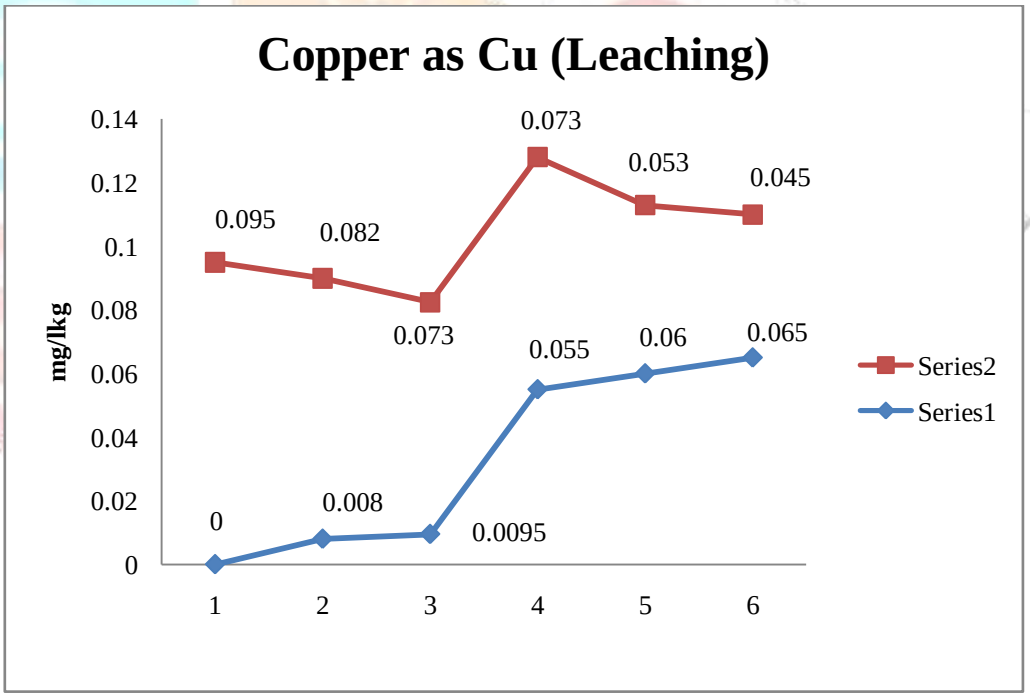


Copper (Cu)

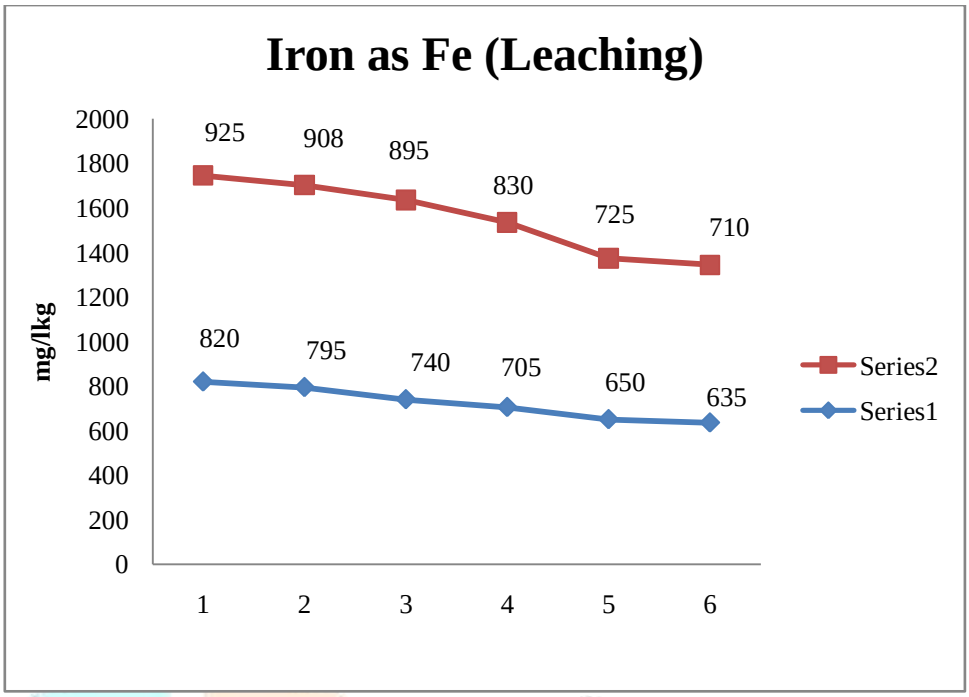
Fig.4.concentration reduction of different W/B ratios



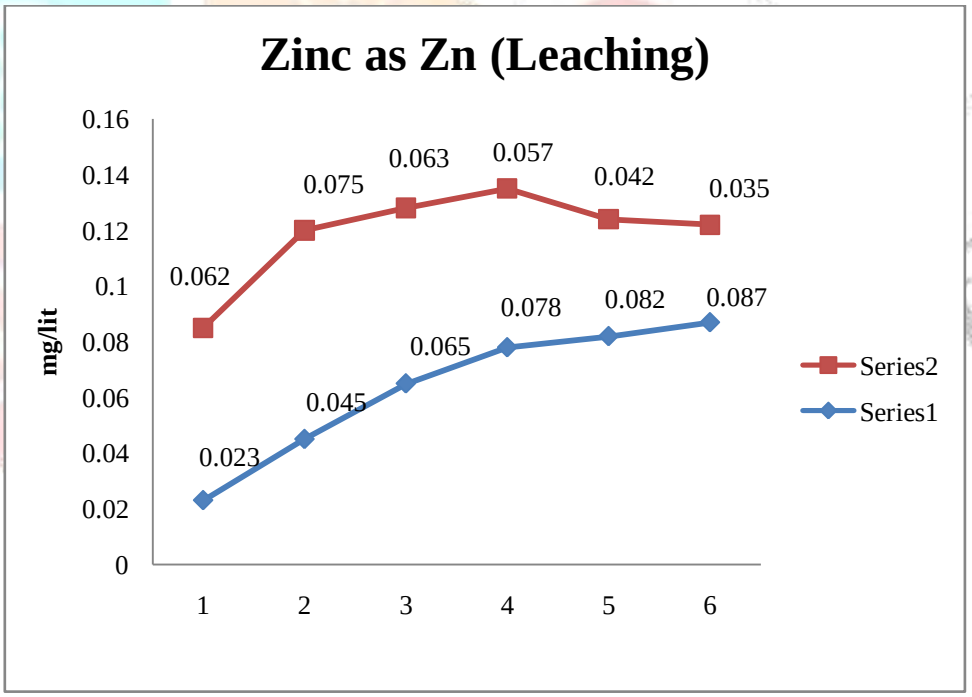
TCLP test result for Chromium (Cr)



TCLP test result for Copper (Cu)



TCLP test result for Iron (Fe)



TCLP test result for Zinc (Zn)

Fig.5.leaching properties of different W/B ratios

Table .1. Leaching concentrations of specimens

Water / Binder ratio	Metal parameters	Leaching concentration mg/kg 28 days curing time	
		Sludge + fly ash (M)	Sludge +fly ash + OPC (A)
M1	Chromium	0.3	0.087
	Lead	0.210	0.110
	Copper	0.095	0.000
	Zinc	0.062	0.023
	Nickel	0.072	0

	Iron	925	820
M2	Chromium	0.285	0.080
	Lead	0.205	0.008
	Copper	0.082	0.045
	Zinc	0.075	0.0045
	Nickel	0.069	0
	Iron	908	795
M3	Chromium	0.245	0.067
	Lead	0.185	0.0095
	Copper	0.073	0.065
	Zinc	0.063	0.065
	Nickel	0.052	0.051
	Iron	895	740
M4	Chromium	0.195	0.059
	Lead	0.175	0.085
	Copper	0.073	0.055
	Zinc	0.057	0.078
	Nickel	0.0475	0.072
	Iron	830	705
M5	Chromium	0.13	0.056
	Lead	0.16	0.076
	Copper	0.053	0.06
	Zinc	0.042	0.082
	Nickel	0.037	0.078
	Iron	725	650
M6	Chromium	0.10	0.047
	Lead	0.045	0.065
	Copper	0.045	0.065
	Zinc	0.035	0.087
	Nickel	0.02	0.082
	Iron	710	635

In addition, heavy metals, (Mn, Cd, Pb, Zn, Fe, Ni, Cu, Cr) amounts in sludge mix specimens kept in 28 days curing period. The W/B ratios are shown in fig 3 the concentration variations for each metal are given in different figures for A and M type cubes. In the A type mix sludge the fly ash and OPC quantity increased, the concentration of heavy metals decreased. The M type mix also shows a considerable decrease of heavy metal concentration compared to A type mix.

Table .2. Heavy metal content of the waste raw sludge and lime stabilized sludge.

Parameters	Raw sludge mg/kg	Raw sludge + lime mg /kg					Leaching for 30 % lime (EPA 1311 TCPL)
		10 %	20 %	30 %	40 %	50 %	
Mn	200	140	181	219	219	287	22
Cd	BDL (DL:10)	BDL	BDL	BDL	BDL	BDL	12
Pb	BDL (DL:10)	BDL	BDL	BDL	BDL	BDL	22
Zn	317	274	223	206	182	169	112
Fe	869	2294	2835	3595	4160	4952	1360
Ni	BDL (DL:10)	BDL	BDL	BDL	BDL	BDL	-
Cu	72	40	34	31	29	28	5
Cr	19848	14113	11693	9755	7916	6457	126

It could be observed that the loading metal amounts were comparatively less than the metal amounts in sludge specimens. The figure shows the higher the W/B ratio, the higher the metal amounts in sludge specimens. The significant charges with W/B ratio for leaching amount were observed however the chromium – leaching amount for A6 grade mix is 0.047 and 0.10 for M6 grade sludge mix. It shows the measuring quantity of fly ash with OPC decreases the leaching concentration.

It was observed that hazardous compounds in the hazardous waste was stabilized by S/S. it was also observed that the waste was no environmental pollution after S/S which was suitable for safe land disposal, while the untreated waste create toxic to the environment as per EPA and RCRA standards.

7. Conclusion:

This research work investigate the stabilization of the hazardous compounds of the tannery sludge by using S/S technology and solve the in the sludge management system for tannery industries.

The following were the conclusion of this research work:

- The raw sludge mixed with lime has to be reducing the heavy metal concentration up to 33 %.
- The lime mixed sludge added with fly ash the process stabilize the heavy metals and decreases the concentration to a extent of 41 %.
- The lime mixed sludge added with fly ash and OPC the heavy metal concentration reduced up to 43 %.
- The compressive strength measurement has been used to determine the efficiency of the S/S process for the tannery sludge. The compressive strength of sludge specimens show that the higher W/B ratio. The compressive of the sludge specimen were less than 28 days the maximum strength of M3 cubes is 1.17 N/mm^2 and minimum of M6 cube of 0.40 N/mm2 but A6 mix shows 7 N/mm^2 of maximum strength A1 mix shows 1.21 N/mm^2 minimum compressive strength. All the M and A mix matrix show that satisfy the standards of EPA and RCRA safe landfill conditions. Also there S/S sludge has been suitable for direct landfill.
- The solidification and stabilization process was not show high concentration pollution in the sludge. Te leaching test results showed the heavy metallic chemical substance was removal efficiency has been 80 to 95 %.
- The compression and leaching test results shows the results of M and A series sludge mixed cubes, the A mix matrix that is sludge + fly ash + OPC shows better results than sludge + fly ash mix M series for safe and secured landfill.

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