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Use of Hazardous Sludge Waste generated in the Common Effluent Treatment Plants as Fuels/Co-fuels - Viabilities with respect to total Organic Carbon, Calorific value and Ash content - an investigation

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ABSTRACT

Three Common Effluent Treatment Plants (CETP) are in operation treating about 3,150 M^3 day^{-1} of toxic industrial effluents generated in various bulk drugs & pharmaceuticals, dye & dye intermediates and chemical industries located around the capital city of Hyderabad. These CETPs treat the effluents by employing equalisation / neutralisation, sedimentation, aerobic stabilisation process (activated sludge process) followed by sedimentation and sludge thickening. During the process of the treatment, an amount of about 2000 tons $year^{-1}$ of sludge waste (on dry basis) is generated, which is being disposed off in a secure landfill with proper treatment. These sludge wastes are considered as hazardous wastes as per the Indian regulatory "Hazardous Wastes (Management and Handling) Amendment Rules, 2000".The primary or inorganic sludge waste [generated during the primary clariflocculation or dissolved air floatation (DAF) process] and secondary or biological sludge (generated in the process of activated sludge process) samples have been collected separately, from the three CETPs. The dried sludge wastes are tested for total organic carbon (TOC), calorific value and ash content at 900^{O}C, for verifying the viability to use these sludge wastes as fuels or auxiliary fuels in incinerators, boilers or cement kilns. The calorific values of the sludge wastes are found to be directly proportional to the TOC values and indirectly proportional to the ash content. Calorific values of all except the primary sludge wastes of CETP-1 & 3 have a range between 2500 – 3000 K. Cal Kg^{-1} and rated as equivalent to 'F' grade coal.

Keywords: CETPs, Sludge Waste, TOC, Calorific value, Ash content and Fuels.

INTRODUCTION

The concept of Common Effluent Treatment Plants (CETP) came into reality in 1989, in the state of Andhra Pradesh and three CETPs are in operation today, at **(a)** Industrial Development Area, Jeedimetla, Rangareddy district, **(b)** Industrial Development Area, Patancheru and **(c)** Industrial Development Area, Bollaram, Medak district of Andhra Pradesh, India, with different treatment capacities. These CETPs are meant to oxidize/stabilize/mineralize the organic load (COD and BOD) to a large extent and to reduce the inorganic load to some extent by combining the industrial effluents with domestic sewage.

Sludge is generated mainly in the, **(a)** Primary clariflocculator, as a result of coagulation of inorganic and organic colloidal particles followed by sedimentation in presence of alum or synthetic coagulants. **(b)** Aeration tanks (Activated Sludge Process) as a result of stabilization/mineralisation/oxidation of organic matter present in the industrial effluent by the action of microorganisms, in presence of oxygen. Part of the sludge generated in the ASP is returned back into the aeration tank for maintaining the food/microorganisms (F/M) ratio. Primary sludge, generated in the clariflocculator or DAF and excess sludge generated in the ASPs, which are in the form of slurry with high moisture content are thickened. The thickened sludge presently is being dumped in the treatment, storage, and disposal facility (TSDF) a engineered secure landfill located at Dundigal village, Rangareddy district of Andhra Pradesh.

Objective: In many developed countries, different types of hazardous wastes are being burnt in the incinerators particularly in the cement kilns [1] along with the cement raw materials for many years, with desired results. Cement kilns provide an excellent alternative for destruction of hazardous wastes because of high temperature (1400^{O}C) and long residence time in the rotary kilns. The destruction efficiency of polychlorinatedbiphenyls (PCBs) in cement kilns is about 99.99997% [2-4].Green Peace estimates about 8,00,000 tons of hazardous wastes are in USA using cement kilns each year [5] as supplementary fuel in the production of cement. These hazardous wastes with high calorific value include refinery waste sludge, paint residues, spent lubricant oils, contaminated soils, etc. are being used as co-fuels in the cement kilns, will not only result in the destruction of the same but also utilized as co-fuel. Sludge wastes generated in the CETPs are also expected to contain organic carbon in appreciable quantity. Hence, the sludge wastes generated in the CETPs have been tested for calorific value, ash content at 900^{o}C and total organic carbon, for evaluating their fuel value not only to check the utility option as fuel or co-fuel, but also to find a way for the destruction of toxic organic constituents, in incinerators or cement kilns. Otherwise these wastes have to be dumped in secure landfills, which need more space than required for incinerated ash, and with potential chance of contamination of environment with toxic organic substances. The above tests have been carried out on the dried samples. This paper will help the CETP managements and the regulatory authorities as well in the safe handling and disposal of the hazardous sludge wastes generated by them (CETPs). The main objective of the study is to verify the viability for using these sludge wastes generated in the CETPs as fuels or auxiliary fuels with respect to their important parameters TOC, calorific value and ash content at 900^{0}C.

MATERIALS AND METHODS

Sampling: Two representative samples, one primary and one secondary sludge wastes have been collected from each CETP, i.e. 6 samples from the three CETPs. Three rounds of such sampling have been carried out in a time span of one year at regular intervals, in the year 2000. Sludge samples have been collected as per the standard procedures laid down in wide-mouth borosilicate glass bottles.

Sample treatment: The sludge samples thus collected are subjected to air-drying followed by oven-drying at 105^{o}C for one hour to remove moisture. These dried samples are made into fine powder with the help of mortar and pestle and stored in wide-mouth glass bottles for the estimation of TOC, ash content at 900^{o}C and calorific value.

Estimations

TOC: Total Organic Carbon content has been estimated by chemical oxidation method using strong oxidizing reagent, potassium dichromate in acidic medium [6].

Ash Content: The ash content of the sludge wastes determined by heating the sample at 900^{0}C in a Muffle Furnace [Bureau of Indian Standard specifications IS: 1350(part-I), 1969].

Calorific Value: Calorific Value of the dried sludge samples have been estimated by using ADVANCE ISOTHERMAL BOMB CALORIMETER [Bureau of Indian Standards Specifications IS: 1359-1959 and British Standards Institution (BS 1016: part–5:1967].

RESULTS AND DISCUSSION

Table 1. Total organic carbon as c (% w/w).

CETP		ROUND-I	ROUND-II	ROUND-III	AVERAGE
CETP - 1	Primary	16.42	26. 31	25.45	22.73
	Secondary	26.21	40.56	39.08	35.28
CETP - 2	Primary	35.64	42.13	37.70	38.49
	Secondary	47.85	48.86	49.36	48.69
CETP - 3	Primary	3.64	4.90	7.30	5.28
	Secondary	42.83	55.17	48.66	48.89

Examination of the above results (table-1), the average TOC values of the three primary sludge wastes are less in comparison with those of the secondary sludge wastes. The primary sludge waste of CETP-3 has the minimum value with 5.28% and the secondary sludge wastes of CETP-2 and CETP-3 have the maximum values with 48.69 and 48.89%w/w respectively.

Table 2. Ash contenet at 900^{o}C **(% w/w).**

CETP		ROUND-I	ROUND-II	ROUND-III	AVERAGE
CETP - 1	Primary	46.62	47.02	47.86	47.17
	Secondary	41.15	35.69	40.99	39.28
CETP - 2	Primary	33.48	36.23	41.02	36.91
	Secondary	14.18	22.65	22.48	19.77
CETP - 3	Primary	57.95	58.21	60.80	58.99
	Secondary	26.62	17.13	17.65	20.47

Above table-2, which shows the ash content values at 900^{o}C, reveals that the values of primary sludge wastes (dried at 105^{o}C) of the three CETPs are high in comparison with that of secondary sludge waste (dried at 105^{o}C). The primary sludge waste of CETP-3 with the ash content maximum with 58.99 and the secondary sludge waste of CETP-2 with the ash content minimum i.e. 19.77.

The values given in the table 1 of TOC and table 2 of ash content shows that the secondary sludge wastes of the three Common Effluent Treatment Plants are enriched with organic matter and in turn organic carbon in comparison to those of primary sludge wastes.

Table 3. Calorific value (K.Cals.Kg^{-1}).

CETP		ROUND-I	ROUND-II	ROUND-III	AVERAGE
CETP - 1	Primary	1,088.0	1,749.0	1,669.0	1,502.0
	Secondary	2,151.0	2,942.0	2,384.0	2,493.0
CETP - 2	Primary	2,966.0	2,504.0	2,432.0	2,634.0
	Secondary	3,432.0	2,673.0	3,107.0	3,071.0
CETP - 3	Primary	276.0	392.0	655.0	441.0
	Secondary	3,204.0	3,075.0	2,817.0	3,032.0

From the above table it is clear that the average calorific values of the primary sludge wastes of the three CETPs are less in comparison with the secondary sludge wastes. It is also clear from the values that the primary sludge waste of the CETP-3 having the minimum i.e. 441.0 Cal.kg^{-1} and the secondary sludge wastes of CETP-2 and CETP-3 with the maximum i.e. 3,071.0 and 3,032.0 kcal kg^{-1} respectively.

CONCLUSIONS

1) The primary and secondary sludge wastes generated in the CETPs cannot be considered or used as fuels in incinerators or in cement kilns as such, as they contain moisture about 70 to 90% and hence, they required to be dried before considering them to be used as fuels or co-fuels.
2) Except the primary sludge wastes of CETP-I and CETP-3, rest of the sludge wastes (Primary and Secondary sludge of CETP-2 and Secondary sludge wastes of CETP-I and CETP-3) with the Calorific value from 2,500 to 3,070 k.cal. kg^{-1} can be compared with that of the Calorific value of D-Grade Coal, which is being used as fuel in many industries in the boilers.
3) Calorific values of these sludge wastes (dried) are directly proportional to the amount of Total Organic Carbon present i.e. more the TOC of the sludge waste more the calorific value.
4) It is also suggested that the calorific value of these dried sludge wastes can further be enhanced/improved by mixing / blending with the other wastes like paint residues, waste lubricant oils, distillation still residues or even with the high calorific value grade coal in suitable proportions.
5) The high concentration values of TOC of these primary and secondary sludge wastes (except the primary sludge waste of CETP-3) which ranges from 16.42 to 55.17, suggests these sludge wastes are enriched with organic matter, which includes various potentially hazard organic substances. Land filling of these substances hence, is not suggestible without incineration, which otherwise will lead to environmental pollution like toxic gas formations, emission and formation of toxic leachate, thereby giving room for the contamination of ground and surface water with toxic organics.
6) Hence, destruction of these organic rich sludge wastes at high temperatures in the incinerators and cement kilns is suggested because of their calorific value, which are almost equivalent to naturally available ‘F‘grade coal [10](Cement kilns are preferred because they provide high temperatures up to 1400^{o}C, which effectively destroy the organic matter).
7) If it is preferred to use as fuel or co-fuel in cement kilns, it is necessary to know the inorganic chemical composition of the sludge wastes, as the same may alter or affect the quality of the cement. It is suspected that these sludge wastes will be containing considerable amount of water-soluble salts like sodium and potassium as chlorides and sulfates, which are unwanted materials in the manufacture of

cement. However these salts can be removed easily by water washing before injecting the sludge wastes (dried) into the kiln.

8) The process of pyrolysis of the dried sludge wastes at 650^{o}C may also be considered, which may yields high calorific value organic portion of the sludge as distillate. This distillate can be used as fuel / co-fuel in the incinerators or cement kilns, which is devoid of inorganic material. The ash residue either can be land filled or can be used as raw material in the brick making or cement manufacturing depending on the chemical composition. Pyrolysis of the municipal solid waste [7] has yielded high calorific value distillate and gaseous products.
9) These sludge wastes contain appreciable amounts of toxic heavy metals [8] and it is necessary to monitor the toxic metals in the stack emissions of the incinerators.
10) Improper incineration of industrial wastes including sludge wastes containing halogenated organic compounds may sometimes results in the formation of highly toxic, non-biodegradable and persistent compounds "DIOXINS"[9].These CETP sludge wastes are also suspected to contain halogenated organic compounds and hence, incineration of the same should be done under controlled conditions to avoid the formation toxic dioxins.

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