Assessment of Sugar Effluent on Soil Contamination analysed by SEM

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ABSTRACT

Sugar industries plays major role in the environment pollution. The organic effluent (spent wash) discharged by such industries is one of the most complexes, troublesome and strongest organic industrial effluent having extremely high BOD and COD values. Assessment on the effect of sugar effluent application on soils were characterised by analytical experiment was SEM (Scanning Electron Microscope). The soil - pollutant interaction was critically analyzed and reported to explain the effect of sugar effluent on commercial (bentonite) and natural soil properties. The experiments were conducted under batch and continuous mode operation using sugar effluent contaminated soil samples with highly clay and silt content. Application of sugar effluent improved the physical and chemical properties of soil by reducing the bulk density and increasing the water holding capacity. The present study showed that the sugar effluent was highly loaded with organic pollutants along with harmful heavy metals which showed significant effect on soil quality and chloride, sulphate present in sugar effluent was reduced by adsorption of sugar effluent through the soil. In this investigation soil columns were developed, and effect of liquid limit, plastic limit and shrinkage limit under expansive and normal soil conditions evaluated, and to achieve soil behaviour under SEM result of soils have been used.

Key words: Sugar Effluent, Commercial and Natural soils, Soil – pollutant interaction, SEM.

1. INTRODUCTION

The 295 distilleries in India produce 2.7 billion litters of alcohol and generating 40 billion litres of wastewater annually. The enormous sugar wastewater has potential to produce 1100 million cubic meters of biogas. The population equivalent of sugar wastewater based on BOD has been reported to be as high as 6.2 billion which means that contribution of sugar waste in India to organic pollution is approximately seven times more than the entire Indian population. The wastewater from distilleries, major portion of which is spent wash, is nearly 15 times the total alcohol production.

2. EXPERIMENTAL INVESTIGATIONS

Sources and collection of effluents: Sugar effluent sample was collected from Gingeetaluk, Villupuran district. The characteristics of sample of effluent were analysed adopting the standard test procedure and results obtained are given in Table 1.

Effluent parameters: The effluent parameters, namely, pH, Electrical Conductivity (EC), alkalinity, Total solids, Total Dissolved Solids (TDS), Total Volatile Solids (TVS), Chloride, Sulphate, Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD), were estimated as per APHA Standard Methods (2005), for characterizing the effluent, and to determine the outflow from the experimental set-up (i.e. soil-column which is described later), at specified intervals.

Selection of soils: Two types of soil samples namely commercial (Bentonite) and natural soils were chosen for the present study to determine the independent behavior when it is artificially contaminated with the sugar effluent. The natural soil sample used in this study was collected in Gingee region and commercial soil available in market is used. The commercial (Bentonite) and natural soils thus collected are henceforth referred to as CSand NS. The characteristics of the sample of soils were analyzed adopting the standard test procedure and the results obtained are given in Table 2.

3. Experimental setup: One-dimensional column method is considered best suited to understand soil-pollutant interactions, as it permits investigations of various flow rates and retention times. Although several investigators have adopted one-dimensional soil-column, the methodology (who have investigated the variation of flow rate and concentration of pollutant/(s) with respect to hydraulic travel times) is considered here but only as a con ceptual model" since their methodology is not a true representation of field conditions relevant to the present study. Further modifications were made to it, to suit the present investigations so as to represent/simulate the field conditions, in the laboratory model

Table.1.Characteristics of Sugar Effluent

Parameters	Raw Effluent
pH	4.30
EC (mS)	3.78
Cl^-	35450
SO_4^{2-}	25600
PO_4^{3-}	224
COD	156000
BOD	54200
Fe	5200
Mn	1500
HCO_3^-	43859

Note: All values in mg/L, except pH, Electrical conductivity

Table.2.Characteristics of Commercial and Natural Soils (CS& NS)

Parameters			CS - Initial	NS - Initial
Visual Classification	Colour		Light yellowish	Light brown
	Odour		No	No
	Texture		Smooth	Smooth
	Dilatancy		None	None
	Toughness		Low	Low
	Dry strength		High	Low
	Shine test		Medium	Dull
Sieve Analysis	Hydrometer analysis	Clay (%)	35.5	27.5
		Silt (%)	64.5	72.5
	Wet Sieve analysis	Silt & Clay (%)	85	65
		Sand (%)	15	35

Description of experimental setup: The fabricated experimental setup was used for batch-mode. "HRT is defined as time taken by the first droplet of the effluent to flow from inlet to outlet of soil column. The batch –mode was operated to study the chemical equilibrium that gets established between various types of soils and the pollutants of the wastewaters, whereas, continuous-mode of operation was aimed at analyzing and reporting" soil-pollutant interactions (with respect to HRT) as applicable to field conditions (i.e. discharge of wastewater on soil is continuous with varying flow rate and concentration of pollutants). The fabricated experimental setup was used for batch-mode. "HRT is defined as time taken by the first droplet of the effluent to flow from inlet to outlet of soil column. The batch –mode was operated to study the chemical equilibrium that gets established between various types of soils and the pollutants of the wastewaters, whereas, continuous-mode of operation was aimed at analyzing and reporting" soil-pollutant interactions (with respect to HRT) as applicable to field conditions (i.e. discharge of wastewater on soil is continuous with varying flow rate and concentration of pollutants). Fig. 1 shows the schematic view of the single soil column of the experimental setup

Preparation of soil specimen: The soil samples (weighing 3.750kg) were mixed with 1:3 ratio of (effluent: water) corresponding to its optimum moisture content and each were loaded in the soil columns indicated as ST1, ST2. The soil sample was collected at an interval of 30 and 90 days for soil testing from the soil columns.

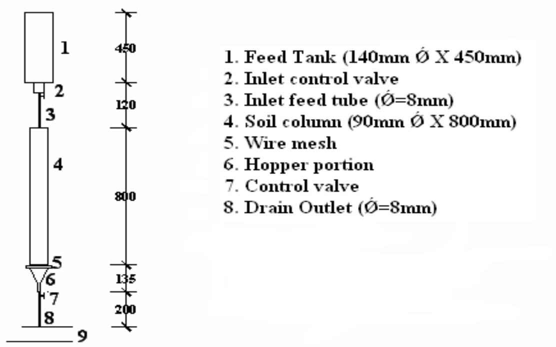

Fig.1.Schematic diagram of the single soil column of the experimental setup

4. RESULTS AND DISCUSSION

Analytical test (Commercial and Natural soil):

SEM Analysis: Scanning Electron Microscopy analysis showed the morphological images and EDAX data for before contaminated soil CS in Fig. 2 and Fig. 3 for after 90 days contaminated soil by sugar effluent. The images showed flocs are formed on surface of soil and the EDAX data indicates CS soil contain higher level (20.95%) of Si element. Then also showed amount of N, P, K, S, Cl, Al, Na, Ca, Mn, and Fe present in soil. The result showed N, P, K, S percentage should be increased by adsorption of nutrients on soil. Si, Na, Mn, Fe was reduced due to leaching of effluent in soil. Fig. 4 and Fig. 5 showed before and after 90 days contaminated soil by sugar effluent. Natural soil also contains Ag and Ni in L and K shells respectively.

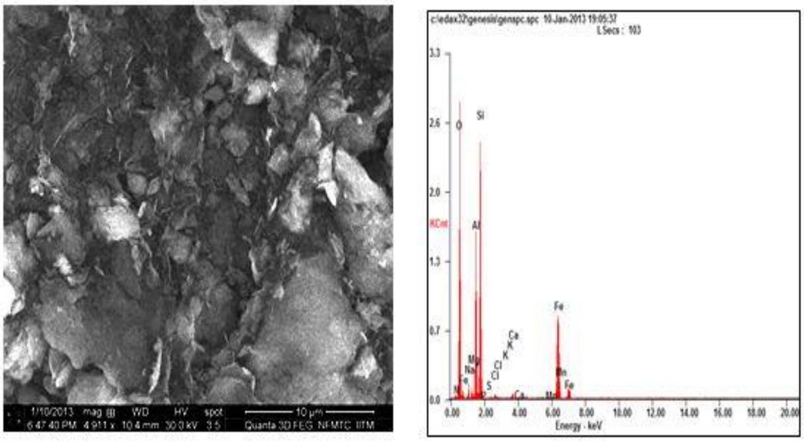

Fig 2. SEM analyses on soil CS before artificial contamination of sugar effluent

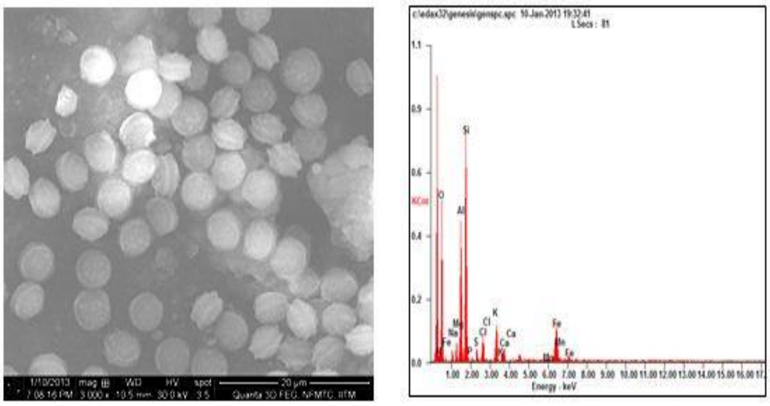

Fig.3.SEM analyses on soil CS after 30 & 90 days artificial contamination of sugar effluent

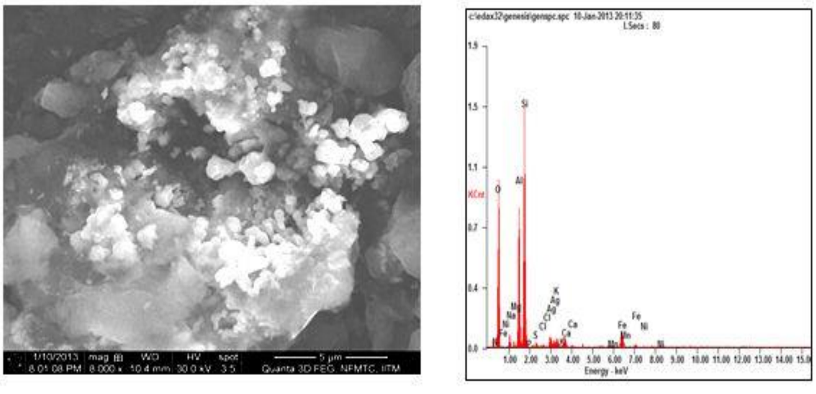

Fig 4. SEM analyses on soil NS before artificial contamination of sugar effluent

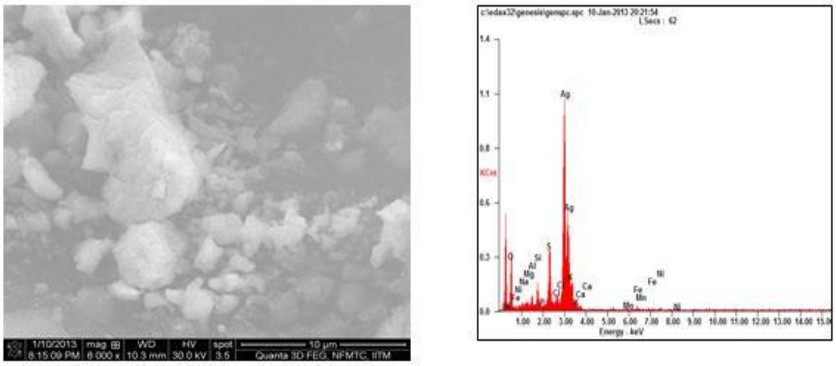

Fig.5.SEM analyses on soil NS after 30 & 90 days artificial contamination of sugar effluent

5. CONCLUSION

SEM analysis showed N, P, K, S percentage was increased by adsorption of nutrients on soil. Si, Na, Mn, Fe was reduced due to leaching of effluent in soil CS and NS. The morphological images showed flocs are formed on surface of soils. The Sulfate and Orthophosphate was decreased on CS and NS during batch and continuous mode due to adsorption on soil. Naturally soils have higher level of nutrients like N, P, K, S etc.

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