

SPECTROPHOTOMETRIC DETERMINATION OF SODIUM LAURYL SULPHATE AS A PRIME ANIONIC SURFACTANT AND CONTAMINANT IN CENTRAL EAST CHHATTISGARH (DURG-BHILAI REGION)

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ABSTRACT

Surfactant-spectrophotometric method for Sodium Lauryl Sulphate (SLS) coupled with acridine orange (ACO) reagent has enhanced sensitivity for determining anionic surfactant (AS) contaminants, including dangerous chemicals incorporated in the ground and surface potable water through various industrial and domestic sources and has been utilized in a potentially reactive urbanized industrial site of Central East Chhattisgarh (Durg-Bhilai). This paper focuses on the potential application of the method, a patented technology, on domestic, potable, agricultural and industrial sewage waste in this potentially urbanized site (Durg-Bhilai) of Central India. The study identifies the major pollutant spots the source and the points of its spread that would be helpful in identifying not only the potential sources of contamination but also the reasons embarking the mobility of the surfactant spread. Further this work also tends to determine the viability of these potential applications as applied to a large area.

Key Words : Spectrophotometer , Sodium Lauryl Sulphate, Durg-Bhilai, Waste Water

INTRODUCTION

With the advent of detergents during the late 50s a major revolution of surfactants took place. Detergents act as both sequesters as well as surfactants. Surfactants are surface-active substance that lowers the surface tension of the solvent. With a hydrophobic group bearing a radical of 10-20 carbon atoms and a hydrophilic moieties ionic or nonionic depending upon the type of surfactant¹ they attain a pseudo-level of self-association called micelle² beyond a particular level of surfactant concentration critical micelle (CMC) which actually is the responsible factor for the cleansing action of the surfactants. The various classes of surfactants ionic surfactants including both anionic and cationic constitute approximately two-third of the various surfactants, 90% of which is mainly contributed by anionic surfactants. Among various anionic surfactants SLS is a widely used anionic surfactants used in modern times by most of the countries.

Being an anionic surfactant, known for its strong detergent properties, structurally one end of the molecule is charged and therefore has an affinity for water, and the other end is non-polar and soluble in fats/oils. SLS has a negatively charged sulfonate group as its "hydrophilic" end and a saturated 12-carbon chain for its "lipophilic" end. SLS has a faint odor of fatty substances and at room temperature, occurs as white or cream-colored crystals, flakes, or powder³, or a clear to

yellowish thick fluid. SLS is stable under ordinary conditions of use and storage but is incompatible with strong acids or strong oxidizing agents⁴. No specific information was located regarding the mode of action of SLS as an herbicide. In general, the principle value of soap-based herbicides (like SLS) is in their capacity to penetrate green plant tissue and disrupt cellular structure, leading to dehydration and eventual death⁵.

In general, the major use of SLS is as a synthetic chemical surfactant¹ for emulsion polymerization⁶. Other major uses include the following: in the electroplating industry as an emulsifier; as a wetting agent and adjuvant in insecticides; as an emulsifier and penetrate in varnish and paint remover; in the formulation of injection-molded explosives; as a model surfactant and reference toxicant in aquatic and mammalian toxicological testing; as a whipping agent and surfactant in foods; and as a cleaning agent in a wide variety of personal care products, such as toothpastes, shampoos, bubble baths, shaving creams - any product that requires a thickening effect and the ability to create a lather. HPD (2004) lists⁷ household products that include SLS. SLS is included as one of 31 "Active Ingredients which may be in minimum risk pesticide products" which are exempt to Section 25(b) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)⁸⁻⁹. SLS is included as one of more than 3,000 total substances that together comprise an inventory often referred to as "Everything Added to Food in the United States (EAFUS)"¹⁰ determined by the U.S. Food and Drug Administration (FDA)¹⁰ Center for Food Safety and Applied Nutrition (CFSAN)¹⁰. Although environmental impacts regarding pollution from SLS are not direct but indirectly it affects the biological cycle. This paper presents a patented method of identifying the potential spots of SLS contamination as a major anionic surfactant in newly formed Chhattisgarh state and its environmental impacts relating to a accelerated urbanization and industrial development in the studied spot in the recent years.

EXPERIMENTAL

10 mL Samples solution to which 100 μ L of Acridine Orange (5×10^{-3} M) and 100 μ L of glacial acetic acid was added, and the resultant was extracted with 5 mL of toluene, shaken for 1 minutes and allowed to stand for 5 min. followed by isolation of the organic layer and its subsequent measurement at 467 nm spectrophotometrically systronic 105.

A calibration curve was obtained for SodiumDo-Decyl sulphate concentration ranging from 0.1 to 6 ppm for which a fluorescent yellow colour layer was obtained.

Sampling and Analysis.

Various water samples from contaminated area including sites of drained industrial out flows and domestic sewage samples were collected in eight portions of 100 cm³ of sample at a distance in Erlenmeyer flasks respectively and the temperature and pH were simultaneously recorded. The flasks were incubated at 25⁰C and the total amount of SLS in each flask was determined. The

relative degradation of the concentration was also simultaneously investigated with the same river water sample at the same time.

The beaker was incubated at 25 μ cube/30 revs min²¹.

Investigation of SLS concentration was carried under three major demarcated sites.

1. Source of outflow of the industrial and sewage waste.
2. Place of accumulation of the dumped sewage.
3. Ground water near the source of accumulation.

RESULT AND DISCUSSION

The outcome of the three major categories of contaminant source of SLS (Table 1) revealed that the extent of SLS usage was more widespread in domestic and industrial waste as compared to agricultural waste. A negative degree of kurtosis in domestic sewage waste as compared to the other two was also indicative of the fact that the uniform application of the chemical was more in the later than in the former case.

Monitoring the SLS concentration in sixteen major flowing sewage streams during 2006 to 2007 (Table 2) showed that with values showing a wide degree of variation maximum of 5.94 ppm to as low as 0.42 ppm, the Percentage deposition of SLS during dumping was higher as compared to that during flowing as revealed in fig.1 Apart from the factors of flow rate and TDS, a flowing condition was associated with different anionic exchanges and other parameters of water which showed the following results as shown in fig.1

Depending upon their SLS concentration in the sampling streams of heavily drained sites from industrial wastes and garbage domestic wastes were segregated and their SLS concentrations were separately monitored according to their location of source, area of their downstream flow which include 16 substations each 2 kms apart from each other and area of their dumping and their concentration determined as shown in Table 2. These values showed a marked variation in the SLS concentration with outflow from the source and their ultimate drainage in to the sink. The sedimentation rate of SLS during flow and after dumping indicated a significant value of SLS is deposited during dumping rather than during flow which in turn may be a probable reason for a high value of SLS concentration in the nearby ground water source near the dumping sink site of the stream rather than near the flow site as is evident in the SLS concentration values of ground water of bore holes and wells sampled near the dumping site. Estimation of other water parameters shown in fig. including Sulphate, chloride, dissolved Oxygen, alkalinity and pH reveals that for a mean pH variation SLS concentration varied significantly with Total alkalinity, chloride and dissolved oxygen. While the Sulphate change showed negative correlation with the SLS concentration shown in Fig.2 The correlation is an indicative that SLS concentration in the solution might be showing ion displacement reactions with prominent ions like Sulphate or

HCO_3^- , CO_3^{2-} , Cl^- or OH^- , the dissolved oxygen in turn provides necessary oxidizing or reducing conditions for this variation. This fact is strongly supported by analyzing the depth variation of SLS with DO shown in fig 2 which indicated that while the SLS concentration was more in the depth than in surface the dissolved oxygen showed a negative correlation with both distance from the surface and also with the surfactant. Correlation statistics indicated that while major studied water parameters behaved correlatively with the surfactant, mainly dissolved oxygen and chloride varied reciprocally to the surfactant concentration. This might be strong indicative of the fact that anions including Sulphate, HCO_3^- , CO_3^{2-} , or OH^- may serve for the ion exchange reaction catalyzed by opposing behavior of chloride conditions due to DO. The variation of SLS concentration with other water parameters is shown in Table.3 and fig.3

Correlation study of SLS with other studied water parameters however revealed that while the DO and chloride concentration varied significantly with depth a might be major factors for varying SLS concentration, uniform replicate study of these parameters in different stations revealed that the surfactant variation was reciprocally related with Sulphate while rest other parameters excluding chloride showed a almost same correlative behavior as with depth. This again was supportive of prime role played by Sulphate, chloride and dissolved oxygen in varying the surfactant concentration its release or its sedimentation. This also finds supports from the major application of these anions chloride or Sulphate during chlorination, bleaching action or as fertilizers Sulphate application.

Prediction of Environmental Concentration:

The environmental exposure assessment is an integral part of the ecological risk assessment. The environmental concentration is determined either from monitoring results or by calculation according to the environmental exposure model (specific discharge conditions, emission volume, flow rate, environmental fate, bio degradation, removal in sewage treatment plants etc.⁸). Here the prediction of environmental concentration of SLS is determined from the monitoring data of the listed drained streams adopting statistical analysis mechanism[2]. The statistical SLS concentration obtained from raw data listed in Table 1. From a conservative point of view, in the risk assessment, 95 percentile of the observed data was used in the prediction of the environmental concentration of SLS. It is expected to be relatively high value in the environment. The maximum value is often applied data when the data are limited. Concerns regarding application of SLS during the last 40 years with the advent of rapid industrialisation and urbanisation in the studied area was calculated through study of the replicate site from 2004-2007 and a regression model obtained from the three year study showed a accumulation rate of SLS in tons per year depending on the discharge rate of the sewage approximately 10^8 gallons of sewage water in Sheonath river was calculated (fig.4) which revealed approximately 18 tons of SLS discharged in the river last year. Linear regression shows there is an

approximately fair correlation ($R^2=0.88$) with the slope close to unity (1.02) confirming the similarity in the calculated and predicted value. Despite other factors regarding environmental degradation or losses in the concentration of SLS with time, the study shows that increasing SLS concentration has a marked effect on creating anoxic condition in water (depleting DO) and eutrophication which in turn affects the aquatic life, hence is a matter of concern in the area in view of rapid urbanization coupled with depletion of potable water quality, waste dumping and depleting ground water level in the area which necessitates the study and development of risk assessment guidelines for Public health and awareness and to adapt to their local, national or regional assessment systems and to ensure that the study may be of use to different jurisdictions and various applications, such as chemicals management assessments and setting environmental quality objectives.

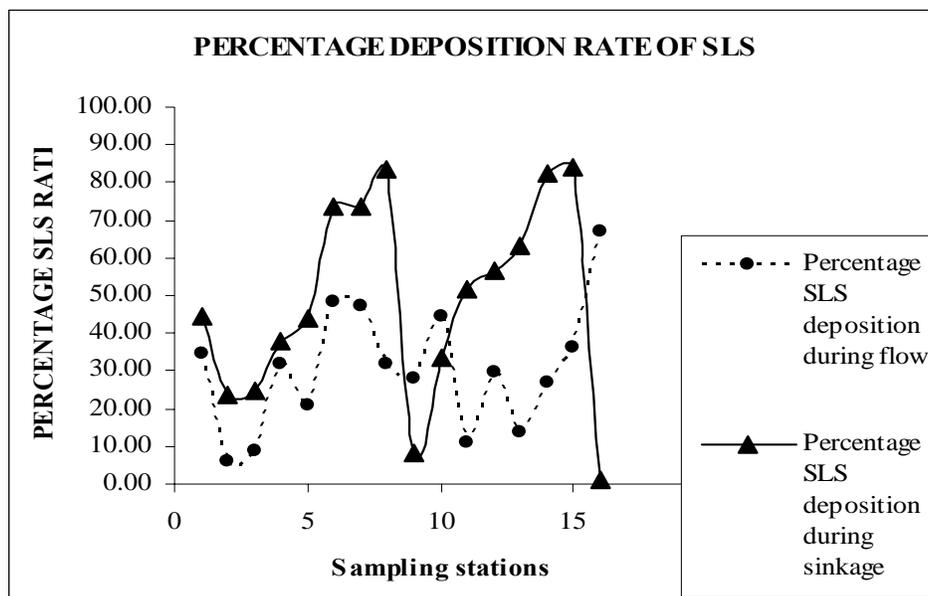


Fig. 1. Comparative SLS deposition percentage rate during flow and during dumping.

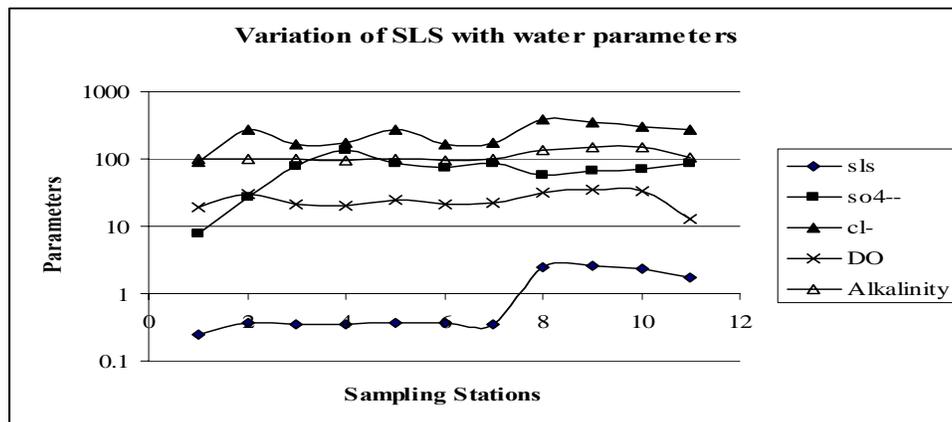


Fig. 2. Variation of SLS concentration with other water parameters in the area.

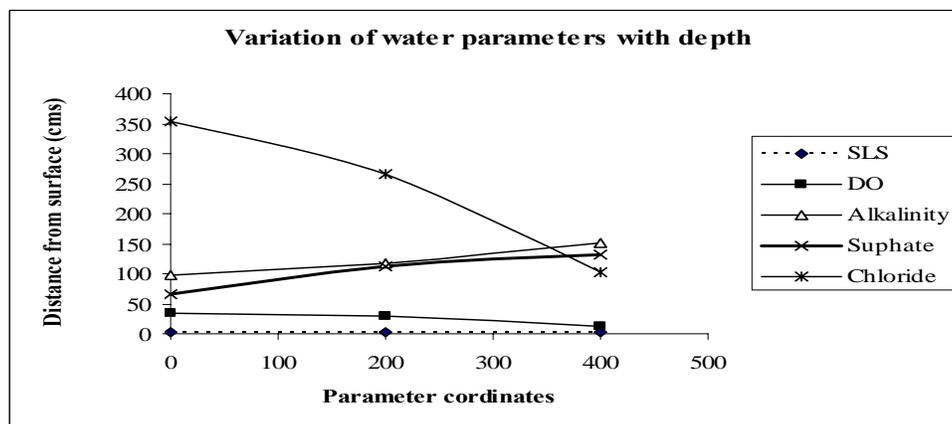


Fig 3. Variation of SLS concentration (ppm) and other water parameters with depth.

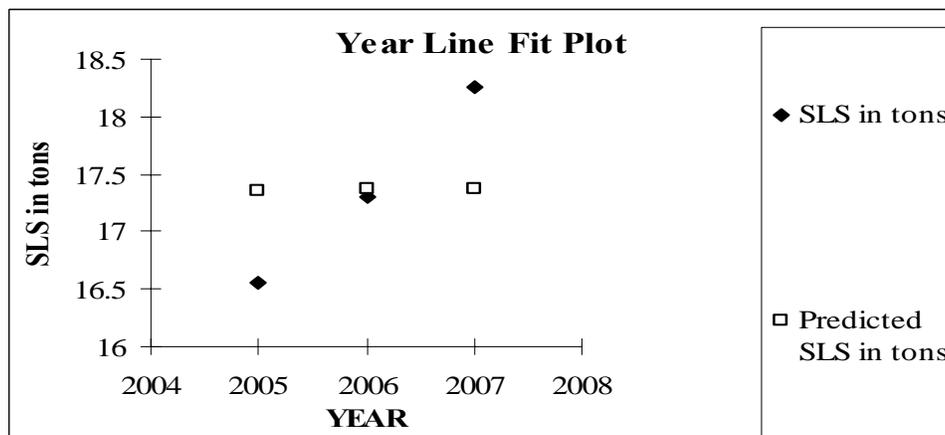


Fig. 4. Year line Plot during 2004-2008 of SLS deposited in Tons annually.

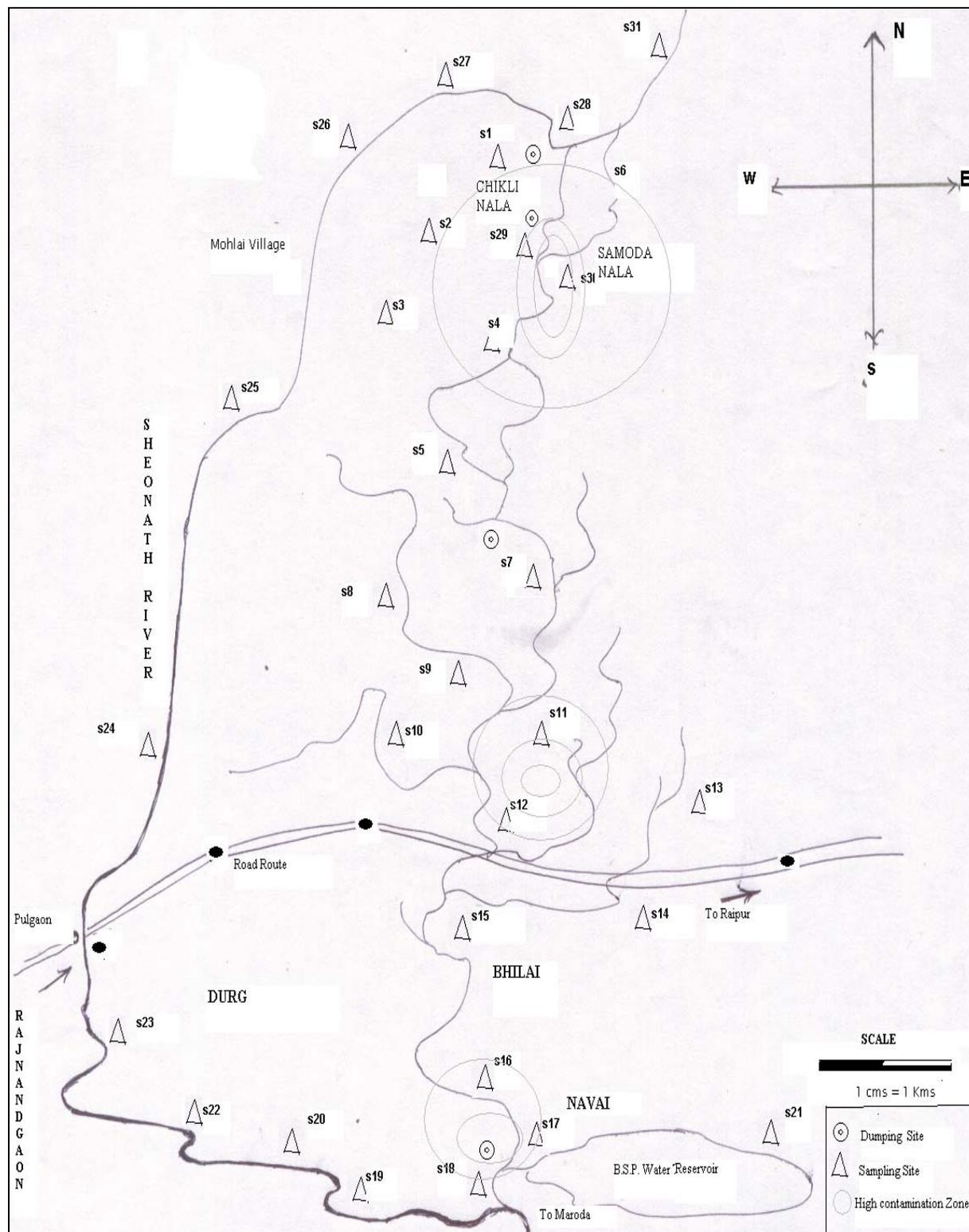


Fig 5. Studied Location Durg-Bhilai Chhattisgarh-Central India

Table1. Statistical analysis of SLS concentration (ppm) in major demarcated spots of the studied location

Statistical parameter	Domestic waste	sewage	Industrial waste	Agricultural waste
Mean	1.05		1.03	0.41
Standard Error	0.12		0.11	0.08
Median	1.12		0.93	0.30
Mode	1.76		0.32	0.32
Standard Deviation	0.65		0.58	0.42
Sample Variance	0.42		0.33	0.18
Kurtosis	-1.35		1.42	9.43
Skewness	-0.14		0.06	2.79
Range	0.11-2.03		0.17-1.98	0.03-2.14
Confidence Level (95.0%)	0.24		0.22	0.16

Table 2. Comparative SLS concentration (ppm) at source, flow and sink of 16 major sewage streaming station flowing across the main heart of city.

Sampling station	Near starting Source of the sewage	At Flowing region of sewage	At dumping site of sewage
S1	0.98	0.64	1.15
S2	1.76	1.65	1.26
S3	1.22	1.11	1.48
S4	1.76	1.2	1.94
S5	1.94	1.54	2.76
S6	1.05	0.54	2.03
S7	1.92	1.01	3.84
S8	1.26	0.86	5.28
S9	1.54	1.11	1.02
S10	1.76	0.98	0.65
S11	0.98	0.87	0.42
S12	1.75	1.23	2.84
S13	1.67	1.44	3.89
S14	1.42	1.04	5.94
S15	1.02	0.65	4.11
S16	2.87	0.95	0.96

Table 3. Correlation of SLS with other water parameters at depth of a sewage stream.

	Values in SLS deep region of stream	SLS	DO	Alkalinity	Sulphate	Chloride
SLS	0.99	1.00				
DO	-0.77	-0.93	1.00			
Alkalinity	0.99	0.97	-0.99	1.00		
Sulphate	0.98	0.99	-0.89	0.94	1.00	
Chloride	-0.99	-0.96	1.00	-1.00	-0.92	1.00

Table 4. Statistical analysis of SLS concentration (ppm) with other water parameters under uniform depthness in 16 studied streams of the studied area.

Statistical Parameters	Sodium Lauryl Sulphate	Sulphate	Chloride-	Dissolved Oxygen	Alkalinity	pH
Mean	1.05	69.86	239.36	24.78	112.66	7.49
Standard Error	0.30	9.84	27.59	2.11	6.57	0.08
Median	0.36	74.76	271.59	22.65	101.21	7.43
Standard Deviation	1.01	32.64	91.51	6.99	21.80	0.27
Sample Variance	1.01	1065.17	8373.31	48.90	475.09	0.07
Kurtosis	-1.47	1.32	-0.89	-0.75	-0.33	-0.68
Skewness	0.81	-0.22	0.06	0.10	1.25	0.71
Range	0.25-2.65	7.68-132.48	90.64-388.22	12.80-35.60	97.06-152.00	7.19-7.98
Confidence Level(95.0%)	0.68	21.93	61.47	4.70	14.64	0.18

Table 5. Correlation analysis of various water parameters with SLS concentration in uniform depth in 16 studied streams(n=115)

	SLS	SO ₄ ²⁻	Cl ⁻	DO	BOD	Alkalinity
SLS	1					
SO ₄ ²⁻	-0.02	1				
Cl ⁻	0.81	0.01	1			
DO	-0.58	-0.23	0.67	1		
BOD	0.94	0.35	0.24	-0.85	1	
Alkalinity	0.92	-0.13	0.73	0.8	0.54	1

ACKNOWLEDGMENTS

Acknowledgment: Authors are thankful to Director, Prof B. S .Narang & Principal Dr M. K. Kowar for institutional facilities.

REFERENCES

1. L.L.Schramm, Surfactants: Fundamentals and applications in the Petroleum Industry, Cambridge University Press. p. 3. (2000).
2. E Schinoda and J.Hutchinson, *Phys. Chem.* **66**, 577, (1962).
3. Chemfinder. (2006). http://chemfinder.cambridgesoft.com/result.asp?mol_rel_id=151-21-3.
4. PTCL (Physical and Theoretical Chemistry Laboratory Oxford University). Chemical and Other Safety Information: Safety (MSDS) Data for Sodium Dodecyl Sulfate. (2005). http://ptcl.chem.ox.ac.uk/MSDS/SO/sodium_dodecyl_sulfate.html.
5. D.M.Whitacre and G.W. Ware,. *An Introduction to Herbicides*. 2nd Edition (online) (2004).<http://ipmworld.umn.edu/chapters/whitacreherb.htm>.
6. HSDB (Hazardous Substances Data Bank). a. Sodium Lauryl Sulfate (2002). <http://toxnet.nlm.nih.gov/>.
7. HPD (Household Product Database). (2004). <http://householdproducts.nlm.nih.gov/cgi-bin/household/brands?tbl=chem&id=98>.
8. EPA. 2000. Pesticide Registration (Pr) Notice 2000-6: *Notice To Manufacturers, Formulators, Producers and Registrants of Pesticide Products*. Office of Pesticide Programs. http://www.epa.gov/PR_Notices/pr2000-6.pdf.
9. EPA. 25b Minimum Risk Pesticides. Office of Pesticide Programs. (2004).http://www.epa.gov/oppbppd1/biopesticides/regtools/25b_list.htm.
10. FDA (U.S. Food and Drug Administration). EAFUS: A Food Additive Database. (2005).<http://vm.cfsan.fda.gov/~dms/eafus.html>.

(Received: 10 March 2008

Accepted: 21 March 2008

RJC-158)

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