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PHYSICO-CHEMICAL ASSESSMENT AND ANALYSIS OF HAZARDOUS ORGANIC SUBSTANCES FROM TEXTILE INDUSTRIAL EFFLUENTS FROM SACHIN AND KADODARA, GIDC, SURAT, INDIA

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ABSTRACT

Surat GIDC, Gujarat is one of the largest producers in textile industry in India. Since, it is closer to the Arabian Sea, the polluted water is passed in to the sea therefore, it is necessary to characterize hazardous substances from textile effluents. Various physico-chemical parameters like pH, TDS, EC with COD and BOD were determined and used to calculate water quality index and compared with national and international parameters. FTIR confirmed the presence of various functionalities related to organic origin and GC/MS technique revealed the presence of linear, cyclic and polycyclic aliphatic and aromatic organic compounds in all collected sample.

KEYWORDS: *Physico-chemical, BOD, COD, Carcinogenic, Mutagenic, GC/MS, FTIR.*

INTRODUCTION :

Hydrosphere is one of the most important segment of environment. Water plays an important role in various life processes of living organisms, supporting the life process by virtue of its unique properties. The overall development of human being revolves around water, therefore water is an essential component in every aspect of human existence. Quality and quantity of water is the most important factor in determining well- being of human society [1]. However, with the other essential components of environment like air and soil, water is also facing the effects of human activities, now a day's water pollution is continuously increasing because of rapid growth in industrialization and the most important contributors in water pollution are organic pollutants, since they are highly stable in water bodies, resistant to biodegradation and carcinogenic [2]. Different types of industries like textile, plastics, pharmaceutical, paper etc. release large amount of effluents which contain enormous amount of organic moieties and when these discharge released in water bodies without or little prior treatment they can cause serious effects and show carcinogenic, mutagenic and other harmful effects towards aquatic life and eventually towards human being [3], [4].

India is one of the largest textile producer in the world and textile industries are the largest contributor of organic pollutants [4]. Dyes, organic chemicals and its residue released during textile processing, dyeing and printing processes introduce organic pollutants in waste water [5]. Currently, more than100,000 different types of dyes are commercially available and more than 1.6 million tons of dyes are produced annually, and 10–15% of this volume is discharged in water bodies [6]. Even at very less concentration (ppm), colored organic pollutants can be visible and can cause serious problems to water bodies and its residents [7]. Most of the dyes are of coal tar origin and hence possess aromatic organic framework and can undergo anaerobic decomposition to form potential carcinogens which may enter in to human body through food chain. Apart from that, they may trap essential sunlight which is important for photosynthesis and affect oxygen dissolution, increase biochemical oxygen demand (BOD) and chemical oxygen demand (COD) which is not an ideal situation for the existence of any aquatic living species [8], [9].

Oceans are the largest sinks of various types of pollutants, since most of the organic matter in the form of industrial effluent without or little prior treatment is first release in to the smaller and larger rivers and eventually enters in to the seas (Fig 1) therefore, oceans are now a days known as the dumping ground of all types of pollutants [1], [10]. Large number of the textile industrial clusters are situated either near rivers or seas and hence release all types of waste water in these water reservoirs [11]. Most of them ignore pre-treatment processes like biodegradation, coagulation–flocculation, adsorption, ozone treatment, electrochemical processes, reverse osmosis, nano-filtration, advance oxidation process (AOP's) etc. before discharging waste water in to the water bodies and hence continue to add large amount of organic pollutants in to the nearer water reservoirs [12]; [13].

The selected zone Gujarat Industrial Development co-operation (GIDC), Surat, Gujarat, India for this study exist in the immediate vicinity of the Arabian Sea. The textile industries employ different types of chemical processes during textile processing, dyeing and printing and release enormous amount of chemicals like acetic acid, formic acid, oxalic acid, ammonium sulphate, bleaches, caustic soda, organic solvent, wetting agent, softeners, hydrosulphites with variety of organic dyes like disperse, vat, reactive, azo dyes and many more [14]. Therefore, it is very essential to analyze and characterize the effluents which are released by these industries which will eventually enters in to the nearby reservoir through different channels, which in this case is Arabian Sea.

The present work is dedicated to identify various organic substances from these textile waste water effluent and to identify potential hazard for the living organism and ultimately human being. GC/MS and FTIR techniques were helpful to identify organic moieties in selected samples from each cluster and as anticipated reveled large number of linear, cyclic and polycyclic aliphatic as well as aromatic organic substances. Since, effluent from these industries were chemically complex in nature, physico-chemical studies were very informative and proved to be an important tool to analyze the quality of the waste water effluent. Statistical analysis was helpful for the comparison of theses effluent samples with standard water quality parameters and calculation of water quality index was helpful to compare quality of collected samples with ideal values given by various national and international agencies.

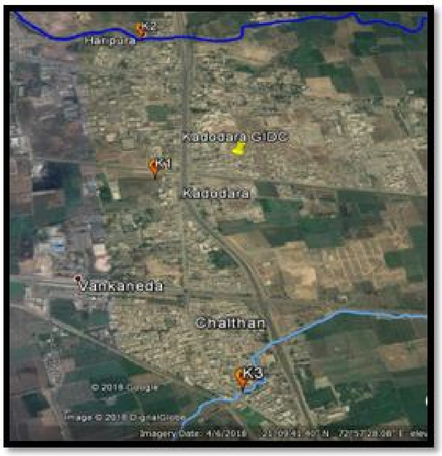
COLLECTION OF WATER SAMPLES AND SAMPLE PREPARATION

Three samples from three different places of Sachin and Kadodara, (GIDC), Surat (Fig 2) were collected. pH and TDS of the samples were recorded immediately after withdrawal. The collect samples were stored in pre-cleaned (Acetone and 1% (v/v) Nitric Acid, Fisher Sci. India), dried and tightly sealed 500 ml dark amber colored glass bottles and stored in thermocol ice box and finally stored in refrigerator for further analysis [15]; [16]. Out of six samples, two samples were chosen for GC/MS and FTIR analysis and all used for the physicochemical studies. The labelling of the collected samples is given in table 1

Solvent extraction process by using pure AR grade Diethyl ether (Sigma Aldrich, India) and separating funnel was employed for the preparation of two collected effluent samples each from both industrial clusters. 25ml of collected effluent sample out of 100ml was extracted with 100 ml of Diethyl ether, then aqueous layer was removed and again 25ml of remaining sample was added in to the organic layer and extracted, this process was again repeated for remaining sample to increase the extraction efficiency [17].

Table 1 Location of samples with graphical representation

Sr.No.	Sample Name	Place of Sample	Source of effluent
	S1	Sachin, GIDC	West side, from industry outlet.
	S2	Sachin, GIDC	North side, from industry outlet.
	S3	Sachin, GIDC	East side, from waste water channel.
	K1	Kadodara, GIDC	Middle, from industry outlet.
	K2	Kadodara, GIDC	North side, from water channel.
6.	**K3**	Kadodara, GIDC	South side, from industry outlet near channel.



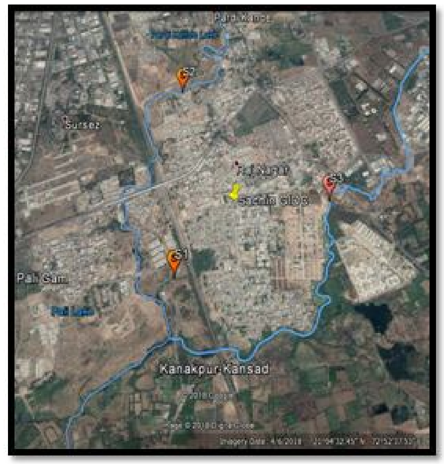


Fig 2 Sample sites at Sachin, GIDC, Surat   Sample sites at Kadodara, GIDC, Surat

Analysis of sample by FTIR and GC/MS

The water sample S1 and K3 were used for the preparation of samples for the FTIR and GC/MS studies by solvent extraction method with the help of Diethyl ether as an organic solvent. The organic moieties found in these samples are discussed with the help of FTIR frequencies of functionalities in **table 2** [18]; [19] and GC/MS information with the help of molecular weight and probable structure is given in **table 3** and **table 4**.

Table 2 Detected organic functionalities from collected effluent sample S1 and K3

Sample- S1			Sample- K3		
S.N.	**Frequency (cm^{-1})**	**Probable Functional Group**	**S.N**	**Frequency (cm^{-1})**	**Probable Functional Group**
1.	3429.52	O-H (broad) hydrogen bonded	1.	3438.15	O-H (broad) hydrogen bonded
2.	2924.65	Alkane sp3 C-H stretching	2.	2924.53	Alkane sp3 C-H stretching
3.	2856.01	Alkane sp3 C-H stretching, C-H aldehyde	3.	1736.88	C=O stretching in aldehydes and Esters
4.	1740.02	C=O stretching in aldehydes	4.	1382.83	N-O stretching
3.	1634.63	N-H bending	3.	1464.44	C-H bending in $–CH_3$ and $–CH_2$
4.	1461.34	sp3 C-H bending in $–CH_3$ and $–CH_2$	4.	1288.45	C-O stretching in esters and ethers

5.	1298.95	C=C aromatic	5.	1265.08	C-O-C starching in ethers
6.	1255.09	C-O-C starching in ethers	6.	1122.57	C-N starching in amines
7.	1106.23	C-O Stretching in alcohols and phenols	7.	1096.86	C-O stretching
8.	951.03	Aromatic C=C-H stretching	8.	929.69	Aromatic C=C-H stretching
9.	804.42	Multi(mono, di, tri) substituted benzene	9.	863.36	Tri substituted benzene
10.	573.15	C-X stretching	10.	722.20	Substituted benzene

GC/MS analysis of effluent samples S1 and K3

Table 3 (a) Detected organic compounds from sample S1

S.N.	**Name of Compound**	**RT**	**M.W.**	**Molecular formula**	**CAS Number**
1.	1,4-dinitro benzene	14.289	168	$C_6H_4O_4N_2$	100-25-4
2.	1,3-dinitro benzene	14.289	168	$C_6H_4O_4N_2$	99-65-0
3.	1,2-dinitro benzene	14.289	168	$C_6H_4O_4N_2$	528-29-0
4.	2,5-dinitro benzoic acid	14.289	212	$C_7H_4O_6N_2$	610-28-6
5.	1-bromo-3-nitrobenzene	14.289	201	$C_6H_4O_2NBr$	585-79-5
6.	4-nitro benzenesulphonamide	14.289	202	$C_6H_6O_4N_2S$	6325-93-5
7.	n-methyl-3-nitro benzenesulphonamide	14.289	216	$C_7H_8O_4N_2S$	58955-78-5
8.	1,3- benzenedisulphonyl difluoride	14.289	242	$C_6H_4O_4F_2S_2$	900401-22-6
9.	Trichloro acetic acid, 2-ethylhexyl ester	14.289	275	C10H17Cl3 O2	16397-79-8
10.	Carbonic acid, bis (4-nitrophenyl) ester	14.289	304	$C_{13}H_8O_7N_2$	5070-13-3
11.	2,6-dinitro benzaldehyde	14.289	196	$C_7H_4O_5N_2$	606-31-5
12.	n-methyl-4-nitro benzenesulphonamide	14.289	216	$C_7H_8O_4N_2S$	6319-45-5
13.	4-nitro benzenesulfonyl azide	14.289	228	$C_6H_4O_4N_4S$	4547-62-0
14.	2,5-di-tert-butyl-1,4-benzoquinone	17.421	220	C14H20O2	2460-77-7
15.	Sulfurous acid, cyclohexylmethyl heptyl ester	17.421	276	$C_{12}H_{28}O_3S$	900309-21-7
16.	Sulfurous acid, cyclohexylmethyl hexyl ester	17.421	262	$C_{13}H_{26}O_3S$	900309-21-6
17.	Sulfurous acid, cyclohexylmethyl iso butyl ester	17.421	234	$C_{11}H_{22}O_3S$	900309-21-3
18.	1,5-diisopropyl-2,3-dimethyl cyclohexane	17.421	196	$C_{14}H_{28}$	900149-58-8
19.	1-hexyl-1-nitrocyclohexane	17.421	213	$C_{12}H_{23}O_2N$	118252-09-8
20.	Cis-1-methyl-3-n-nonylcyclohexane	17.421	224	C6H32	39762-39-5

21.	3-dodecylcyclohexanone	17.421	266	$C_{18}H_{34}O$	138695-42-8
22.	1-(1,5-dimethyl hexyl)-4-methyl cyclohexane	17.421	154	$C_{11}H_{22}$	75736-66-2
23.	1-(1,5-dimethylhexyl) cyclohexane	17.421	280	$C_{20}H_{40}$	56009-20-2
24.	2-piperidinone, n-(4-bromo-n-butyl)	17.421	233	$C_9H_{16}ONBr$	195194-80-0
25.	Pentadec-7-ene, 7-bromomethyl	17.421	302	$C_6H_{31}Br$	900259-58-5
26.	1-(1-hydroxy-1-heptyl)-2-methylene-3-pentyl cyclopropane	17.421	238	$C_{16}H_{30}O$	900157-41-8
27.	10-methylundec-2-ene-4-olide	17.421	196	$C_{12}H_{20}O_2$	900370-40-9
28.	2-isopropyl-5-methylcyclohexyl methanol	17.421	170	$C_{11}H_{22}O$	900223-18-0
29.	2-aziridinone, 1-tert-butyl-3-(1-methylcycloheptyl)	17.421	223	$C_{14}H_{25}ON$	26944-18-3
30.	2,2'-methylene bis[6-(1,1-dimethylethyl)-4-methyl] phenol	25.950	340	$C_{23}H_{32}O_2$	119-47-1
31.	Neoisolongifolene-8-ol	25.950	220	$C_{15}H_{24}O$	900159-36-9
32.	Germacrene d	25.950	204	$C_{15}H_{24}$	23986-74-5
33.	2-tert-butyl-6-methylphenol isopropyl ether	25.950	206	$C_{14}H_{22}O$	900395-19-3
34.	2-methoxy-6-(1-propenyl) phenol	25.950	164	$C_{10}H_{12}O_2$	1076-55-7
35.	2-(2-butoxy-3-rert-butyl-5-methyl benzyl)-6-tert-butyl-4-methylphenol	25.950	396	$C_{27}H_{40}O_2$	27996-20-9
36.	2,3,4,5-tetramethyl benzenemethanol	25.950	164	$C_{10}H_{12}O_2$	20020-94-4
37.	2-tert-butyl-6-methylphenol, n-butyl ether	25.950	220	$C_{15}H_{24}O$	900395-19-1
38.	1-(1,1-dimethylethyl)-3-ethyl-5-methyl benzene	25.950	176	$C_{13}H_{20}$	6630-01-9
39.	4-(2,6,6-trimethyl-1-cyclohexene-1-yl) 3-Butene-2-one	25.950	192	$C_{13}H_{20}O$	14901-07-6
40.	1-isopentyl-4-methoxymethylbenzene	25.950	164	$C_{11}H_{16}O$	73789-85-9

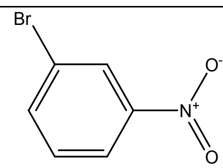
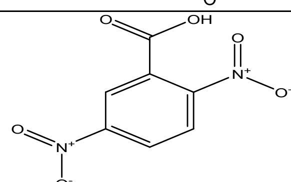
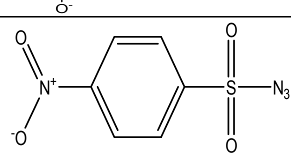
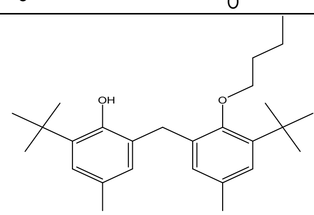
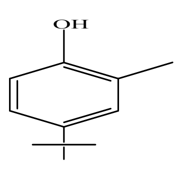
(b) Detected organic compounds from sample K3

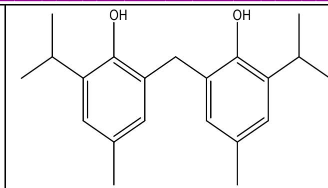
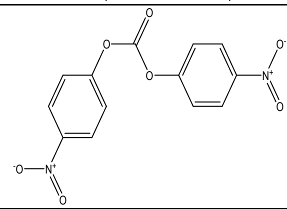
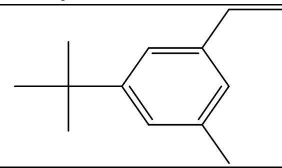
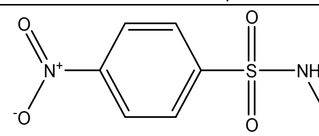
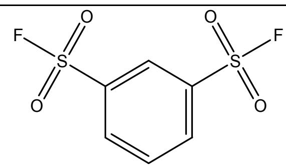
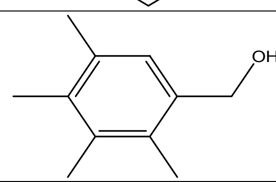
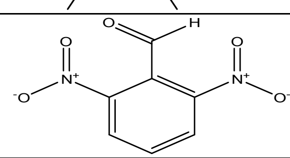
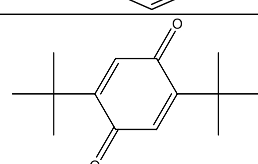
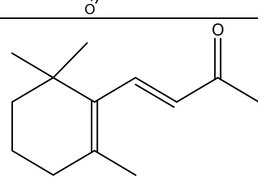
S.N.	Name of Compound	RT	M.W.	Molecular formula	CAS Number
1.	1H-isoindole-1,3(2h)-dione, 2-(2-pyridinyl)	14.289	224	$C_{13}H_8O_2N_2$	59208-49-0
2.	1-hexyl-2- nitro cyclohexane	17.421	213	$C_{12}H_{23}O_2N$	118252-.4-3
3.	2,6-dimethyl quinoline	17.421	157	C11H11N	877-43-0

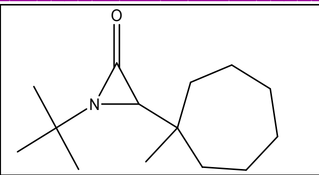
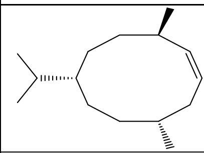
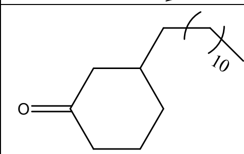
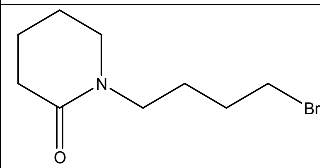
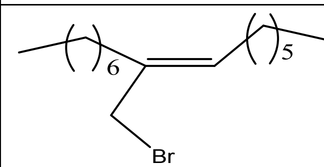
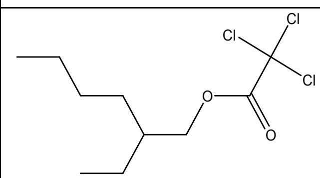
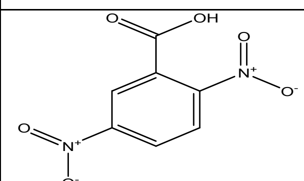
4.	2-piperidinone, N-[4-bromo-n-butyl]	17.421	233	$C_9H_{16}ONBr$	195194-80-0
5.	Pentadec-7-ene,7-bromomethyl	17.421	302	$C_{16}H_{31}Br$	900259-58-5
6.	3-chloro-1,1,2,2- tetramethyl	17.421	132	$C_7H_{13}Cl$	14123-41-2
7.	Sulphurous acid, cyclohexylmethyl heptyl ester	17.421	276	$C_{14}H_{28}O_3S$	900309-22-1
8.	Cis-1-methyl-3-n-nonylcyclohexane	17.421	224	C_6H_{32}	39762-39-5
9.	3-(3,3-dimethylbutyl) cyclohexanone	17.421	182	$C_{12}H_{22}O$	40564-94-1
10.	2-dodecene-1-yl(-)succinic anhydride	17.421	266	$C_{16}H_{26}O_3$	19780-11-1
11.	1,5-diisopropyl-2,3-dimethyl cyclohexane,	17.421	196	$C_{14}H_{28}$	900149-8-8
12.	Sulphurous acid, butyl cyclohexylmethyl ester	17.421	234	$C_{11}H_{22}O_3S$	900309-21-4
13.	2,2'- methylenebis [6-(1,1-Dimethyl ethyl)-4-methyl] phenol	21.528	340	$C_{23}H_{32}O_2$	119-47-1
14.	2-(2-butoxy-3-tert-butyl-5-methylbenzyl)-6-[3-(1.1-dimethylethyl)]	21.528	396	$C_{24}H_{40}O_2$	27996-20-9
15.	2-(4-butylphenoxy)-N2-(2-methoxybenzylideno) acethydrazide	21.528	340	$C_{20}H_{24}O_3N_2$	900264-12-4
16.	1-isopropyl-4-methoxy methylbenzene	21.528	164	$C_1H_{16}O$	73789-85-2
17.	1-(1,1-dimethylethyl)-3-ethyl-5-methyl benzene	21.528	176	$C_{13}H_{20}$	6630-01-9
18.	Modephene	21.528	204	$C_{16}H_{32}$	68269-87-4
19.	15-crown-5	23.654	220	$C_{10}H_{20}O_5$	33100-27-5
20.	1,4,7,10,13,16-hexaoxacyclooctadecane	23.654	264	$C_{12}H_{24}O_6$	17455-13-9
21.	Heptaethyleneglycol	23.654	326	$C_{14}H_{30}O_8$	5617-32-3
22.	15-crown-5	23.654	220	$C_{10}H_{20}O_5$	33100-27-5
23.	2-tert-Butyl-6-methylphenol, isopropyl ether	25.950	206	$C_{14}H_{22}O$	900395-19-3
24.	2-methoxy-6-(1-propenyl) phenol	25.950	164	$C_{10}H_{12}O_2$	1076-55-7
25.	2-(2-butoxy-3-rert-butyl-5-methyl benzyl)-6-tert-butyl-4-methyl phenol	25.950	396	$C_{27}H_{40}O_2$	27996-20-9
26.	2,3,4,5-tetramethyl benzene methanol	25.950	164	$C_{10}H_{12}O_2$	20020-94-4
27.	2-tert-butyl-6-methylphenol, n-butyl ether	25.950	220	$C_{15}H_{24}O$	900395-19-1
28.	1-(1,1-dimethylethyl)-3-ethyl-5-	25.950	176	$C_{13}H_{20}$	6630-01-9

	methyl benzene				
29.	4-(1,1 dimethyl ethyl)-2-methyl phenol	25.950	164	$C_{11}H_{16}O$	98-27-1
30.	3-butene-2-one, 4-(2,6,6-trimethyl-1-cyclohexene-1-yl)	25.950	192	$C_{13}H_{20}O$	14901-07-6
31.	2-tert-butyl-6-methylphenol, n-pentyl ether	25.950	234	$C_{16}H_{26}O$	900395-18-9
32.	1-chloro-1-(3,3-diethoxy-1-propynyl)-2,2,3,3-tetramethyl cyclopropane	25.950	258	$C_{14}H_{23}O_2Cl$	900216-53-0
33.	Bicyclo [3.3.0]octane -2-one, 7-neopentylidene	25.950	192	$C_{13}H_{20}O$	900158-89-6
34.	1-octadecene	28.791	252	$C_{18}H_{36}$	112-88-9
35.	1-docosene	28.791	308	$C_{22}H_{44}$	1599-67-3
36.	Hexadecen-1-ol,trans-9	28.791	240	$C_{16}H_{32}$	64437-47-4

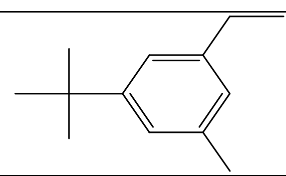
Table 4 (a) Structures of few organic compounds from S1 sample

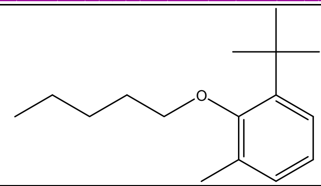
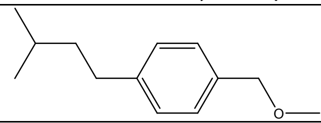
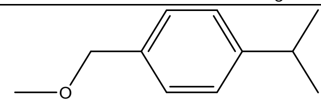
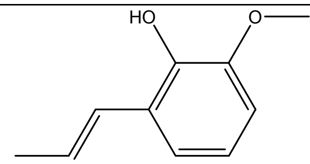
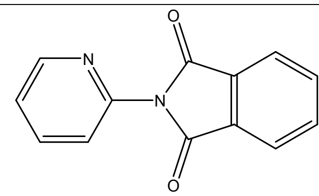
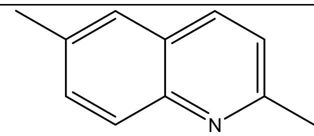
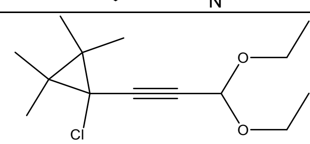
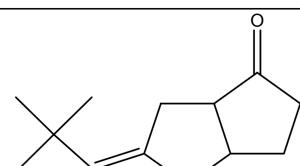
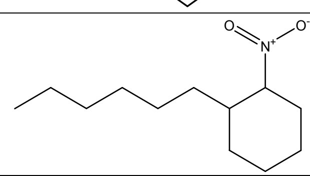
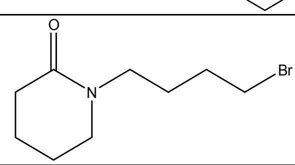
S.N.	**Name of compound**	**Structure**	**M.W**	**Molecular Formula**	**CAS Number**
1.	1-Bromo, 3-Nitro benzene		201	$C_6H_4O_2NBr$	585-79-5
2.	2,5-Dinitro benzoic acid		212	$C_7H_4O_6N_2$	610-28-6
3.	4nitrobenzenesulfonyl azide		228	$C_6H_4O_4N_4S$	4547-62-0
4.	2-(2-butoxy-3-tert-butyl-5-methyl benzyl)-6-tert-butyl-4-methylphenol		396	$C_{27}H_{40}O_2$	27996-20-9
5.	4-(1,1-dimethyl)2-methyl phenol		164	$C_{11}H_{16}O$	98-27-1

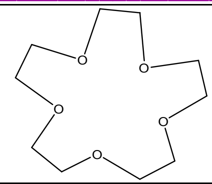
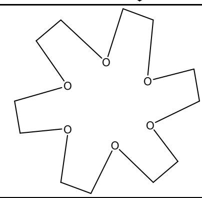
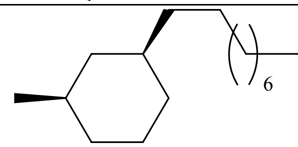
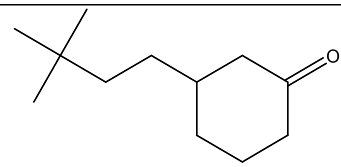
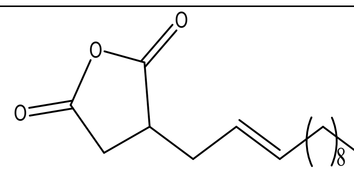
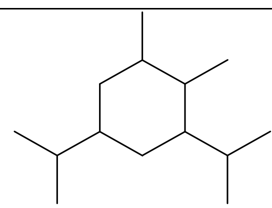
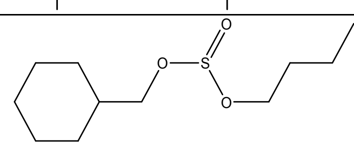
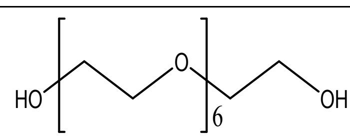
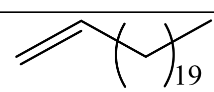
6.	2,2-methylene bis[6(1,1dimethylethyl)] -4-methyl phenol		340	$C_{23}H_{32}O_2$	119-47-1
7.	Carbonic acid, bis (4-nitrophenyl) ester		304	$C_{13}H_8O_7N_2$	5070-13-3
8.	1-(1,1-dimethylethyl)-3-ethyl-5-methyl benzene		176	$C_{13}H_{20}$	6630-01-9
9.	n-methyl-4-nitro benzenesulphonamide		216	$C_7H_8O_4N_2S$	6319-45-5
10.	1,3- benzenedisulphonyl difluoride		242	$C_6H_4O_4F_2S_2$	900401-22-6
11.	2,3,4,5-tetramethyl benzenemethanol		164	$C_{10}H_{12}O_2$	20020-94-4
12.	2,6-dinitro benzaldehyde		196	$C_7H_4O_5N_2$	606-31-5
13.	2,5-di-tert-Butyl-1,4-benzoquinone		220	C14H20O2	2460-77-7
14.	3-buten-2-one,4(2,6,6-trimethyl-1-cyclohexane-1-yl)		192	$C_{13}H_{20}O_8$	14901-07-6

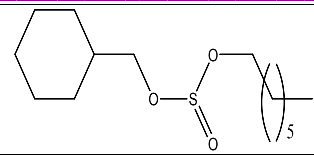
15.	2-aziridinone, 1-tert-butyl-3-(1-methylcycloheptyl)		223	$C_{14}H_{25}ON$	26944-18-3
16.	Germacrene d		204	$C_{15}H_{24}$	23986-74-5
17.	3-dodecylcyclohexanone		266	$C_{18}H_{34}O$	138695-42-8
18.	2-piperidinone, n-(4-bromo-n-butyl)		233	$C_9H_{16}ONBr$	195194-80-0
19.	Pentadec-7-ene, 7-bromomethyl		302	$C_6H_{31}Br$	900259-58-5
20.	Trichloro acetic acid 2-ethylhexyl ester		275	C10H17Cl3O2	16397-79-8
21.	2,5-Dinitro benzoic acid		212	$C_7H_4O_6N_2$	610-28-6

(b) Structures of few organic compounds from K3 sample

S.N.	Name of compound	Structure	M. W.	Molecular Formula	CAS Number
1.	1-(1,1-dimethylethyl)-3-ethyl-5-methyl benzene		176	$C_{13}H_{20}$	6630-01-9

2.	2-tert-butyl-6-methylphenol, n-pentyl ether		234	$C_{16}H_{26}O$	900395-18-9
3.	1-isopentyl-4-methoxymethyl benzene		164	$C_{11}H_{16}O$	73789-85-9
4.	1-isopropyl-4-methoxymethyl benzene		164	$C_1H_{16}O$	73789-85-2
5.	2-methoxy-6-(1-propenyl) phenol		164	$C_{10}H_{12}O_2$	1076-55-7
6.	1,3(2H)-dione, 2-(2-pyridinyl) 1H-isoindole		224	$C_{13}H_8O_2N_2$	59208-49-0
7.	2,6-dimethyl Quinoline		157	C11H11N	877-43-0
8.	1-chloro-1-(3,3-diethoxy-1-propynyl)-2,2,3,3-tetramethyl cyclopropane		258	$C_{14}H_{23}O_2Cl$	900216-53-0
9.	Bicyclo [3.3.0]octane - 2-one, 7-neopentylidene		192	$C_{13}H_{20}O$	900158-89-6
10.	1-hexyl-2-nitrocyclohexane		213	$C_{12}H_{23}O_2N$	118252-4-3
11.	2-piperidinone, N-[4-bromo-n-butyl]		233	$C_9H_{16}ONBr$	195194-80-0

12.	15-crown-5		220	$C_{10}H_{20}O_5$	33100-27-5
13.	1,4,7,10,13,16-hexaoxacyclooctadecane (18-crown-6)		264	$C_{12}H_{24}O_6$	17455-13-9
14.	Cis-1-methyl-3-n-nonylcyclohexane		224	C_6H_{32}	39762-39-5
15.	3-(3,3-dimethylbutyl) cyclohexanone		182	$C_{12}H_{22}O$	40564-94-1
16.	2-dodecene-1-yl (-)succinic anhydride		266	$C_{16}H_{26}O_3$	19780-11-1
17.	Cyclohexane, 1,5-diisopropyl-2,3-dimethyl		196	$C_{14}H_{28}$	900149-58-8
18.	Sulphurous acid, butyl cyclohexyl methyl ester		234	$C_{11}H_{22}O_3S$	900309-21-4
19.	Heptaethyleneglycol		326	$C_{14}H_{30}O_8$	5617-32-3
20.	1- docosene		308	$C_{22}H_{44}$	1599-67-3

21.	Sulphurous acid, cyclohexylmethyl octadecyl ester		430	$C_{25}H_{50}O_3S$	900309-22-6

CAS = chemical abstracts service.

Toxic effects of some organic substances found in sample S1 and K3

It is difficult to relate found organic substances exactly with the toxicity mentioned in the various articles. The essential criteria here is the functional groups and structural similarities. With the help of information of functionalities found in organics in the samples, it is relatively easy to compare these substances with the toxicity of similar substances with identical functional groups towards aquatic organisms and humans reported in literature. The toxicity of few organics from S1 and K3 samples is discussed in the **table 5**.

Table 5 Toxicity of some organic compounds found in S1 and K3 effluent samples

S.N.	Name of organic compound	Toxic effect	References
1.	1-bromo, 3-nitro benzene	Hypoglycaemic, mutagenic, carcino-genic, corrosive and phytochemical effects on aquatic living organisams.	[20, 21]
2.	2-(2-butoxy-3-trert-butyl-5-methyl benzyl)-6-tert-butyl-4-methylphenol	Accumulation in cell by forming hazardous metabolites, disturbs bone marrow functioning and blood cell circulation.	[22]
3.	4-(1,1-dimethyl)-2-methyl phenol	Mutagenic, ruptures cell membrane, reacts with macromolecules like protein and DNA.	[20, 23]
4.	2,2-methylene bis[6(1,1dimethylethyl)]-4-methyl phenol	Mutagenic, carcinogenic, accum- ulation in marine organisms like mangrove clam (Polymesodaerosa) and the mangrove snail (Telescopium telescopium), interacts with enzymes and alters population of small marine species.	[21, 24]
5.	Carbonic acid, bis (4-nitrophenyl) ester	Antidepressant, estrogenic effects, polar anesthetic, toxicity due to incorporation through inhalation, absorption and ingestion, corrosive, high reactivity in cell.	[24, 25]
6.	1-(1,1-dimethylethyl)-3-ethyl-5-methyl benzene	Interferes with signaling pathways in smaller organisms, conversion of a normal cell to a leukemia cell, hematoatoxic activities.	[26, 27]
7.	1,3(2H)-dione, 2-(2-pyridinyl) 1H-isoindole	Textile industries are major source, endocrine disrupting properties, mutagenic alters the population of aquatic biota, possibility of accumulation and incorporation in to	[28]

		the food chain.	
8.	2,6-dimethyl quinolone	Toxic in very small concentration towards soil organisms, strong oxidant towards biomolecules, effects are evident in plants, nematodes and smaller animals.	[29, 27]
9.	Trichloro acetic acid 2-ethylhexyl ester	Biomolecule inhibitor, carbonic anhydrase inhibitor in microorganisms and smaller organisms in water, harmful effects on eyesight of rabbits during lab experiments.	[30]
10.	1,3- benzenedisulphonyl difluoride	Chromosomal aberration, sister-chromatid exchange and related genotoxic effects, non-Hodgkin Lymphoma, kidney and liver cancer.	[29, 27]

Physico-chemical Analysis of effluent samples

Table 6 Physico-chemical parameters of collected effluent samples

Sample	pH	Electrical Conductivity	TDS	Sulphate	Chloride	COD	BOD
S1	9.1	553	3400	89.25	469	1970	692
S2	7.6	442	1954	78.14	323	950	494
S3	8.2	410	2800	86.42	301	1800	587
K1	7.6	388	2300	83.27	357	1550	454
K2	7.8	473	2100	80.17	489	1315	328
K3	7.2	378	1625	92.45	290	760	483
Mean	7.91	440.66	2363.17	84.95	372.83	1390.83	506.33
S.D	0.40	34.73	309.29	1.59	43.50	96.27	113.42
S.E	0.17	14.18	126.27	0.65	17.76	39.31	46.31
WHO	6.5-9.2	1400	500	200	500	-	-
USPH	6.0-8.5	250	500	250	250	-	-
BIS	6.5-8.5	300	500	200	250	-	30
Unit	µmho/cm	µmho/cm	mg/L	mg/L	mg/L	mg/L O2	mg/L O2

Surface water – BIS 2296:1982, **S.D**: Standard Deviation, **S.E**: Standard Error

Physicochemical parameters status of effluent samples

1) pH : pH is a logarithmic scale used to specify the acidity or basicity of an aqueous solution. pH is an essential criteria for water analysis and plays an important role in all vital processes of living organisms. Change in pH value may cause serious problems to aquatic life such as increase in heart rate, curve spine, malformation of head, metabolism and even mortality [31]. The pH values obtain at the sites are within the range of permeable limits of various national and international agencies. Sample S1 and S3 shows slightly basic pH than rest of the collected samples.

2) Electrical Conductivity (EC): Electrical conductivity is a measure of cations as well as anions in water. Increases in EC generally indicates increase in these inorganic species. Change in cationic and anionic concentration is very lethal for the aquatic life and human beings. Liver, kidney, digestive system and nervous systems are highly affected by these cations and anions [32, 33].The collected samples show very much higher EC values, may be because of various unit operation in textile industry.

3) Total Dissolve Solid (TDS): TDS is a measurement of inorganic salts, organic matter and other dissolved materials in water. The important contributors for the TDS values are presence of Na^+, Ca^{2+}, Mg^{2+}, CO_3^{2-}, SO_4^{2-}, Cl^- etc. in water. Change in concentration of these ionic species in water alter the population of different types of species like microorganisms, algae and fishesh [34]. TDS values obtain in the collected samples are dangerously higher than the standard values of water quality, this is a clear indication of presence of various organic as well as inorganic substances in textile water effluent.

4) Sulphates (SO_4^{2-}): Sulphate anaerobic metabolism produces phosphates in water bodies through decomposition of organic matter and phosphates are an essential nutrients for plant, hence excess growth of vegetation which is also known as eutrophication is a common problem throughout the [35, 36]. Presence of sulphates in water samples is very less when compared to the standard values given by various agencies.

5) Chloride (Cl^-): Many textile production process are the main contributor of chlorides in water [14]. Excess of Cl^- can cause serious problems to habitats of aquatic organisms and show harmful effects to human being through its corrosive action [37]. Chloride level in collected samples is at higher site and it is expected because of excess use of chlorinated substances in textile processing.

6) BOD and COD: Oxygen related environmental parameters like DO, BOD and COD are interrelated with each other. Increase in BOD and COD values are attributed to low dissolve oxygen and higher pollution [9]. Samples from both the industrial area show very high BOD and COD value and therefore indicate the presence of organic carbon. This is a cause of concern since high organic carbon decrease the dissolve oxygen level and seriously affects aquatic life.

Pearson Correlation Coefficient (R) data of various parameters

The calculated correlation coefficient (R) for various parameters is given in **table 7**. The correlation coefficient (R) denotes the relationship between two variables. The TDS and pH show strong correlation which is an indication of high salt content in water which is confirmed by Cl^- and EC correlation value (38), TDS and COD are correlated due to the high concentration of organics in to the collected water samples (39). BOD and sulphate correlate due to the participation of sulphates in decomposition of organic matter eventually effect BOD (9).

.

Table 7 Pearson Correlation Coefficient (R) data of various parameters

	pH	**Electrical Conductivity**	**TDS**	**Sulphate**	**Chloride**	**COD**	**BOD**
pH	1						
Electrical Conductivity	0.8373	1					
TDS	0.9678	0.6869	1				
Sulphate	0.1861	-0.0602	0.2125	1			
Chloride	0.5563	0.8039	0.4338	-0.2120	1		
COD	0.8569	0.5204	0.9442	0.1126	0.4341	1	
BOD	0.7326	0.4173	0.7593	0.5242	-0.0988	0.5662	1

Water quality Index (WQI)

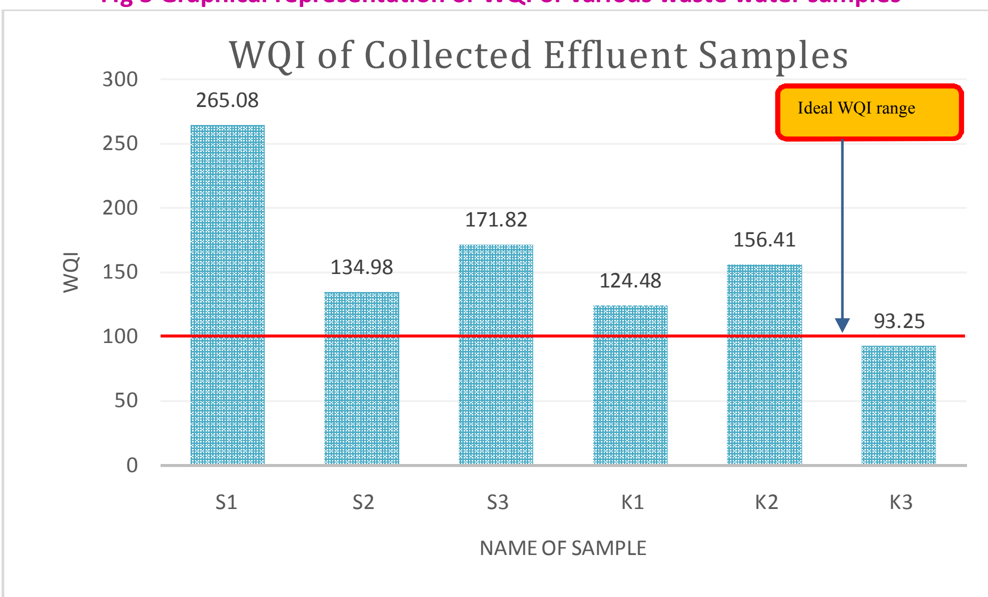
Water quality index (WQI) for various water types is acceptable within the 100 point range, for instance 90–100 range is unsuitable for potable purpose, 70–90 very poor water quality, 50–70 poor water quality, 25–50 good quality water, 0–25 excellent quality. The tasted water parameters such as pH, EC, TDS, sulphate and chloride are essential factors in deciding water quality [39]. The calculate water quality index was found to be at very higher site than ideal WQI values especially from Sachin, GIDC region. Water quality in this region is so poor that it is not even fit for portable purpose. The calculated water quality index is depicted in **table 8**.

Table 8 Calculated water quality index data of collected effluent samples

	S1	S2	S3	K1	K2	K3	Wn	Sn	V_{10}
pH	9.1	7.6	8.2	7.6	7.8	7.2	0.218	7.5	7.0
E.C	553	442	410	388	473	378	0.372	300	0
TDS	3400	1954	2800	2300	2100	1625	0.0036	1000	0
Sulphate	89.25	78.14	86.42	83.27	80.17	92.45	0.01235	500	0
Chloride	469	323	301	357	489	298	0.0075	250	0
Σ Qn	1149.18	607.55	794.39	638.80	739.3	466.19	-	-	-
ΣWn × Qn	163.077	82.80	105.40	76.36	95.95	57.21	-	-	-
WQI	265.08	134.98	171.82	124.48	156.41	93.25	-	-	-

Sn: Standard Value, V_{10}: Ideal value, **Qn**: Quality Rating, **Wn**: Unit weight; **WQI**: Water Quality Index

Fig 3 Graphical representation of WQI of various waste water samples



CONCLUSION:

The core aim of this study was to assess the overall impacts of textile effluents in the industrial zone near Arabian Sea. The successful application of GC/MS techniques leads to the identification of vast number of linear, cyclic, polycyclic, aliphatic as well as aromatic organic contaminants which are released in the form of effluent from these textile industries. The organic moieties which found are either intermediates or byproducts of various textile industry processes. FTIR analysis also confirmed various functionalities such as long chain hydrocarbons, halogenated hydrocarbons, substituted benzene and phenols which are highly hazardous to the biosphere. It is found that the identified organic compounds are highly mutagenic, carcinogenic and alter various life process of aquatic residents and human beings.

Physico-chemical parameters were studied and statistical analysis provided important information which was helpful for the comparison of the collected water samples with standard water quality parameter. It is found that apart from pH most of the found parameters are well above the dangerous level and calculated water quality index values are very much higher than expected values. The most important parameters were BOD and COD which are directly related to the amount of dissolve oxygen in water. BOD and COD values in the range of 700 to 1900 mg/L of O_2 is very much higher than standard values and is the striking indication of severe pollution. Therefore, it is highly recommended not to ignore necessary pre-treatment process like biodegradation, adsorption, reverse osmosis, coagulation–flocculation, nanofiltration, ozone treatment, advance oxidation process (AOP's) etc. before discharging these waste water effluents in to the hydrosphere. Furthermore, high TDS and Chloride levels should be regulate to protect smaller aquatic species. This small initiative from the authorities is important to develop sustainable environment for the aquatic as well as human life.

Conflicts of interest:

There are no conflicts to declare.

ACKNOWLEDGEMENT:

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Fig 1 Map information of Sachin and Kadodara, GIDC, Surat

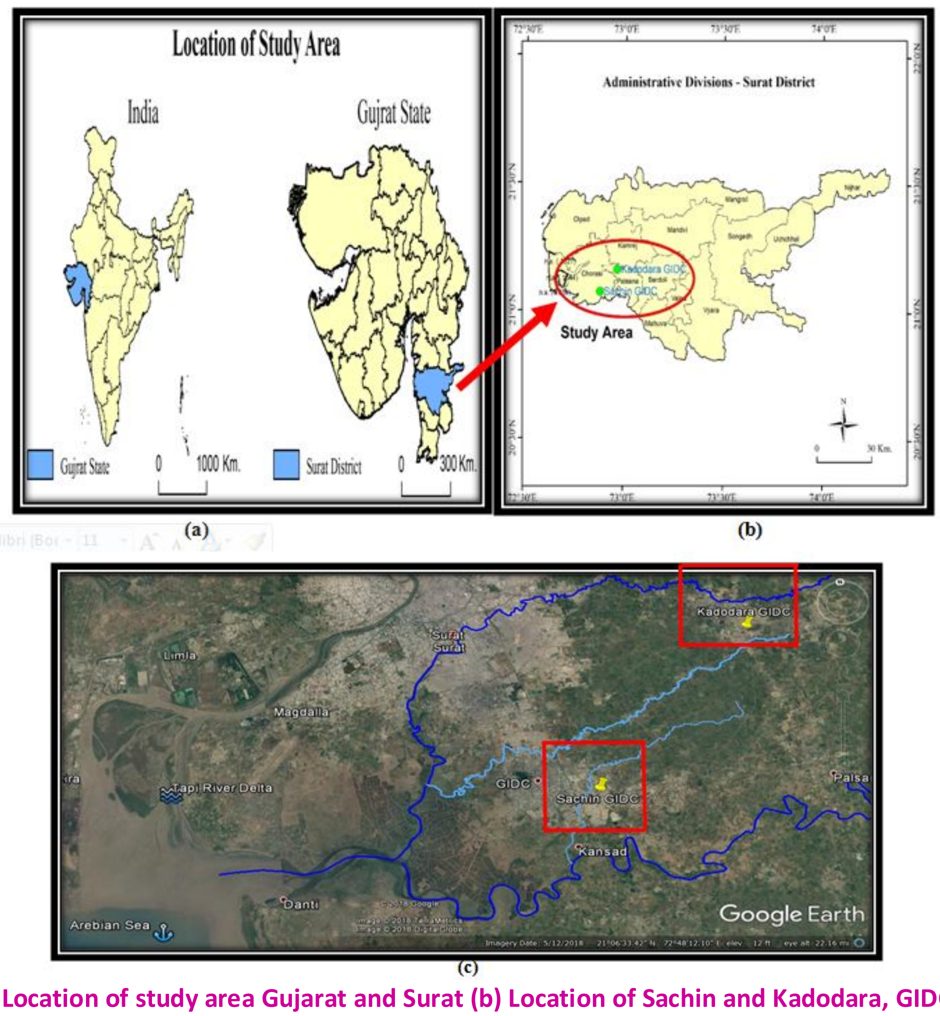

Fig 1 (a) Location of study area Gujarat and Surat (b) Location of Sachin and Kadodara, GIDC, Surat (c) Water passages through Sachin and Kadodara textile industry clusters in to the Arabian Sea.