



A STATISTICAL STUDY ON PHYSICOCHEMICAL CHARACTERISTICS OF INDUSTRIAL WASTEWATER

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ABSTRACT

Industrial wastewater samples were collected from G.I.D.C. Vapi and Ankaleshwar for physiochemical parameters. The values of correlation coefficient (r) in the G.I.D.C., Vapi and Ankaleshwar was in the range of -0.006 to 0.9940 , and 0.0062 to 1.004 , respectively. Large positive correlations were observed in the samples of Vapi G.I.D.C. between pH and BOD, pH and sulphate, TS and BOD, TDS and Mg, F^- and T-P, which large positive correlations were observed in the samples of Ankaleshwar between TS and Cl^- , T-N and OM, T-N and Ca, COD and OM, Ca and Mg. A large negative correlation coefficient (r) value (-0.915) in samples of Vapi was observed for pH and TS. and in samples of Ankaleshwar, it was for TDS and TSS (-0.939). The linear regression analysis of these pairs of parameters has also been carried out.

Key words : Waste water, Physicochemical.

INTRODUCTION

G.I.D.C., Vapi and Ankaleshwar (Gujarat) are amongst the biggest industrial areas in Asia. These areas contain lot of industries including chemical, pharmaceutical, pesticides, textile, dyeing and printing, fertilizers and dairy industries. The quality of water in general and industrial water in particular, may be described by their physical, chemical and microbiological characteristics. However, the number of such characteristics (known usually as water quality parameters) necessary to completely specify the quality of polluted water is quite large. But if we can find some correlations among them specifying a few of the more important ones would suffice to give a rough, but still fairly useful indication of the quality of polluted water. The industrial waste correlation among industrial waste water quality parameters in a specific environment condition have been shown to be useful. In present investigation, the feasibility of this idea for the industry has been demonstrated by systematically calculating the correlation coefficients between all possible pairs of water quality parameters. This study will thus greatly facilitate the task of rapid monitoring the status of pollution of a water body.

MATERIALS AND METHOD

Industrial waste water samples were collected from 6 different locations from Vapi and Ankaleshwar G.I.D.C. Samples were analysed for various physicochemical parameters by following standard methods⁴. The statistics have also been evaluated by standard methods.

RESULTS AND DISCUSSION

The statistical evaluation from physicochemical data of industrial wastewater from Vapi, G.I.D.C. are being summarised in Table 1. The pH value of the samples is in the range 9.06–7.8 out of 5 samples and average value with 95% CL were found to be in the range $6.544 \pm (1.5039)$, Electrical conductance varies between 2701–4129 umho/cm and average value with 95% CL were found to be in the range $3363 \pm (2845.83)$. The total dissolved solids were very high and detected in the range of 20 – 1327 mg/lit and average value with 95% CL were found to be in the range $0.4776 \pm (0.1886)$ High value of total dissolved solids contributes to high value of Hardness (250 – 2850 mg/lit) of waste–water and average value $1324 \pm (1031.34)$ Total suspended solid Varies between 3–127 mg/lit with the average value with 95% CL were found to be in the range $0.06 \pm (0.02472)$, such high values imparts high COD, BOD and turbidity to the waste–water (Chakravarthi et al., 1996) The COD observed in between 560–2080 mg/lit, with the average value with 95% CL were found to be in the range $1344 \pm (571.5)$ The high concentration of cation, such as Ca 48–1901.5 mg/lit and Mg 46.26 – 380.52 mg/lit with the average with 95% CL $526.99 \pm (116.54)$ were observed. The value of sulphate 913 – 9834 mg/lit with average value with 95% CL was found to be in the range $5.635 \pm (3.910)$ chloride (624 – 4600mg/lit) were found to be very high as compared with phosphorus (1.08 – 3.51 mg/lit) and nitrate (56–363 mg/lit) with the average value with 95% CL were found to be in the range $1767 \pm (1656.34)$, $1.906 \pm (1.031)$ and $2.16 \pm (1.40)$ respectively, hence the effluents required effectively treatment before fed into land or irrigation.

The statistical evaluation from physico–chemical data of industrial waste water from Ankaleshwar are being summarised in Table 2. The pH of the samples is in the range of 6 to 7.8 out of 6 samples and average value with 95% CL were found to be in the range $6.47 \pm (1.224)$. Electrical conductance varies between 2701 to 3127 umho/cm the total dissolved solids were high and detected in the range of 209 to 4038 mg/lit. The hardness varies between 250 to 2155 mg/lit of the waste–water. The total suspended solids varies between 149 – 361 mg/lit. The high content of organic matter (470 – 1341 mg/lit) result high COD (560 – 1598 mg/lit) of waste–water because chemical oxygen demand measures the recalcitrant (non–biodegradable) organic matter in biologically treated industrial effluents (Malviya et al., 2001). The high concentration of cation such as Ca (112 – 593 mg/lit) and Mg (41.6 – 35105 mg/lit) result high hardness were observed. The total kjeldahl nitrogen was determined in between 1050 – 1312.5 mg/lit. The value of sulphate (157 – 913.5 mg/lit), chloride (527 – 4600.9 mg/lit) were found

tobe high phosphate (1.07 – 3.51 mg/lit) and nitrite (1.29 – 1.69 mg/lit) were found sodium and potassium found 4170 – 6000 mg/lit, 2100 – 5400 mg/lit respectively.

Table 1. Physico–chemical characteristics of the industrial effluent in mg/L (Vapi)

Parameter	Min.	Max.	Mean	S.D.	Std. error	95% CL
pH	4.06	7.8	6.54	1.483	0.6654	6.544 ± (1.5039)
EC	2701	4129	3363.8	620.63	1259.21	3363 ± (2845.834)
TS	23	1365	537.8	508.9	228.2	537.8 ± (515.73)
TDS	20	1327	478.2	507.537	227.59	478.2 ± (514.35)
TSS	3	174	69.4	63.84	28.62	69.4 ± (64.68)
COD	560	2080	1344	563.98	252.9	1344 ± (571.5)
BOD	160	3280	1429	1319.6	659.8	1429 ± (491.2)
Cl ⁻	624.8	4600.8	1767	1634.41	732.8969	1767 ± (1656.3469)
SO ₄ ²⁻	0.9135	9.8348	5.635	3.865	1.7302	5.6358 ± (3.9104)
NO ₃ ⁻	0.56	3.63	2.166	1.371	0.6208	2.16 ± (1.40317)
Hardness	250	2850	1324	1017.65	465.349	1324 ± (1031.34)
Fl ⁻	2	12	6.14	4.08	1.832	6.14 ± (4.141)
Ca	48.096	1901.5	526.9	772.8	346.56	526.9 ± (783.225)
Mg	49.264	380.52	972.3	122.56	51.566	194.466 ± (116.540)
T-Ph	1.08	3.51	1.906	1.27	0.4563	1.906 ± (1.03125)
I-Ph	0.47	1.91	1.064	0.664	0.2895	1.064 ± (0.6542)
O-Ph	0.40	1.91	0.84	0.609	0.2728	0.84 ± (0.6085)

The numerical values of the correlation coefficient (r) for 17 water quality parameters (Vapi, GIDC) are tabulated in Table 3. The correlation coefficient (r) ranged all the way from – 0.92 (pH and TDS). The high positive correlation is observed for pH with BOD (0.9654) Inorg – ph (1.45), EC with Hardness (0.967), TS with TDS (1.042) TS with BOD (0.9495), TS with mg (0.956). TDS with BOD (0.968), TDS with mg (0.9375), TSS with Hardness (1.51), TSS with Ca (1.51), TSS with Inorg – Ph (1.391), SO₄²⁻ with Fl⁻ (1, 227), SO₄²⁻ with Hardness (1.02), SO₄²⁻ with total-Ph (1.3126), NO₃⁻ with Inorg-Ph (0.980), Fl⁻ with Inorg – ph (0.924), Hardness with Mg (1.127). The largest negative correlation coefficient (–0.92) is observed for pH and TDS. The TDS shows small negative correlation with TSS and Ca.

Table 2. Statistical evaluation for the industrial effluent, (Ankaleshwar)

Parameter	Min	Max	Mean	S.D.	Std. error	95% CL
pH	6.00	7.8	6.47	1.323	0.542	6.47±(1.224)
EC	2701	3127	2886.3	189.8	77.8	2886.3±(175.8)
TS	570	4187	1870.5	2481.9	1017.17	1870.5±(2299)
TDS	209	4038	1597	1321.65	541.66	1597±(1224)
TSS	149	361	273.5	305.75	61.15	273.5±(138.19)
Cl ⁻	527	4600.9	1717.56	1458.8	597.9	1717.56±(1351.2)
SO ₄ ²⁻	157.0	913.5	640.38	1255	514.36	640.38±(1162.45)
ALK	260	410	330	57.27	23.47	330±(53.04)
COD	560	1598	1059.6	435.53	178.49	1059.6±(403.4)
OM	470	1341	853	380.81	156.07	853±(352.72)
NO ₂ ⁻	1.29	1.69	1.502	0.150	0.0616	1.502±(0.1392)
T-N	1050	1312.5	1163.6	105.94	43.418	1163.6±(98.12)
Hardness	250	2155	1159.16	260.58	106.79	1159.16±(241.34)
T-Ph	1.07	3.51	1.793	0.9528	0.39052	1.793±(0.882)
In-Ph	0.50	1.91	1.075	0.545	0.223	1.075±(0.5056)
Or-Ph	0.61	1.91	0.718	0.6180	0.2532	0.718±(0.5722)
Ca	112.0	593.0	314.33	221.01	90.579	314.33±(204.53)
Mg	41.60	351.50	158.35	130.56	53.50	158.35±(120.9)
Fe	37	278	166.8	88.27	36.17	166.8±(81.75)
Na	417	600	510.3	866.87	355.27	5103±(802.9)
K	210	540	538.3	468.004	1918	5383±(4334.7)

The numerical value of the correlation coefficient (r) for 17 water quality parameters (Ankaleshwar, GIDC) are tabulated in Table 4. The correlation coefficient (r) ranged all the way from - 0.21 (Hard and potassium), the high positive correlation is observed for TS with Cl⁻ (1.004), T-N with OM (0.93), COD with OM (0.942), T-Ph with org-Ph (0.838), Ca with Mg (0.93), COD with OM (0.942), T-Ph with org-Ph (0.838), Ca with Mg (0.965). The largest negative correlation coefficient (- 0.939) is observed for TDS with TSS. The small negative correlation coefficient (- 0.021) is observed for Hardness with potassium.

Table 3. Correlation Matrix Effluent parameters (Vapi)

	pH	EC	TS	TDS	TSS	COD	BOD	Cl ⁻	SO ₄ ²⁻	NO ₃ ⁻	Hard	FI	Ca	Mg	T-Ph	I-Ph	O-Ph	
pH	1.00																	
EC	0.378	1.00																
TC	-0.915	0.005	1.00															
TDS	-0.92	0.617	1.042	1.00														
TSS	0.1674	0.669	0.0803	-0.0076	1.00													
COD	-0.818	0.682	0.8141	0.790	0.348	1.00												
BOD	0.9654	0.603	0.9495	0.968	0.0358	0.2513	1.00											
Cl ⁻	0.0134	-0.886	-0.272	-0.2668	-0.083	-0.104	0.8021	1.00										
SO ₄ ²⁻	0.6323	0.0339	0.616	-0.515	-1.20	-0.748	0.320	0.492	1.00									
NO ₃ ⁻	0.675	-0.691	-0.888	-0.860	-0.300	-0.227	0.499	0.625	-0.349	1.00								
Hard	0.389	0.1845	-0.046	-0.708	-0.265	-0.328	-0.527	0.3681	1.227	0.888	1.00							
FI	0.180	0.967	0.501	0.433	1.51	0.5318	0.387	0.275	1.020	-0.614	-0.699	1.00						
Ca	0.1053	0.644	0.039	-0.0386	1.512	0.0411	-0.118	0.6100	0.648	-0.273	-0.470	0.877	1.00					
Mg	-0.846	0.5485	0.956	0.9375	0.789	-0.361	0.0289	-0.087	0.7319	-0.001	-0.217	1.127	0.4554	1.00				
T-Ph	0.596	0.0095	-0.786	-0.730	-0.234	-0.709	0.739	0.3405	1.3126	0.625	0.631	-0.677	-0.372	-0.798	1.00			
I-Ph	1.45	-1.062	0.7714	-0.745	1.391	-0.389	-0.641	0.247	1.304	0.980	0.924	-0.634	-0.379	-0.703	0.826	1.00		
O-Ph	0.4611	-0.796	-0.485	-0.440	-0.335	-0.774	0.6114	0.7765	0.528	0.446	0.061	-0.458	-0.171	-0.588	0.7888	0.3146	1.00	

Table 4. Correlation coefficient (r) for different physico-chemical parameters (Ankaleshwar)

	pH	EC	TS	TDS	TSS	Cl ⁻	SO ₄ ²⁻	T-N	NO ₃ ⁻	Hard	COD	OM	T-Ph	Ln-Ph	Org-Ph	Ca	Mg	Fe	Na	K			
pH	1																						
EC	0.1228	1																					
TS	0.2248	0.61	1																				
TDS	0.2147	0.5996	0.4123	1																			
TSS	-0.04	0.3648	-0.932	-0.939	1																		
Cl ⁻	0.0126	0.419	1.004	0.372	0.5443	1																	
SO ₄ ²⁻	-0.051	-0.337	-0.702	-0.703	0.676	0.6699	1																
T-N	-0.3384	0.1583	-0.4522	-0.45	0.3999	0.5347	0.3485	1															
NO ₃ ⁻	-0.3932	0.0099	0.061	0.1138	-0.3358	-0.563	-0.481	0.264	1														
Hard	-0.062	0.567	0.645	0.6442	-0.597	-0.398	-0.928	-0.041	0.551	1													
COD	0.0327	0.5864	-0.015	-0.022	0.141	0.577	0.057	0.799	0.0582	0.0299	1												
OM	-0.112	0.367	-0.296	-0.299	0.3502	0.67	0.3438	0.93	0.056	-0.0062	0.942	1											
T-Ph	0.42	-0.165	-0.22	-0.116	0.217	0.3675	0.646	-0.334	-0.775	-0.113	-0.196	-0.134	1										
Ln-Ph	0.3322	0.2189	-0.194	-0.209	0.4419	0.2366	0.617	-0.134	-0.781	-0.083	0.0507	0.083	0.779	1									
Org-Ph	0.3444	-0.448	0.0038	0.0071	-0.058	-0.098	0.448	-0.395	-0.4121	-0.1854	-0.346	0.481	0.838	0.3045	1								
Ca	0.1899	0.1579	0.407	0.4052	-0.3468	-0.609	-0.8847	0.838	0.5018	0.1121	0.090	-0.0303	-0.606	-0.59	-0.407	1							
Mg	0.1832	-0.039	0.172	0.1706	-0.1344	-0.585	-0.739	-0.0815	0.519	0.0904	0.1044	-0.083	-0.566	-0.59	-0.35	0.965	1						
Fe	0.2056	-0.1766	-0.228	-0.2319	0.2785	0.0603	0.1466	0.08	-0.119	-0.0291	0.1338	0.1441	0.178	-0.491	0.107	0.0762	0.1786	1					
Na	0.3699	0.1393	0.7193	0.7235	-0.742	-0.0455	-0.477	-0.338	0.1426	0.0293	0.0237	-0.1657	0.2068	-0.1204	0.6253	0.3159	0.2259	0.0932	1				
K	-0.2495	-0.287	-0.0338	-0.0176	-0.239	-0.2112	0.1525	0.459	0.5714	-0.021	0.237	0.353	-0.1094	-0.5421	0.3475	-0.1324	-0.0664	0.0623	0.432	1			

Table 5. Linear correlation and regression equation for some parameters and their predicted values (Vapi)

Parameters	a	b	r	Regression equation	Predicted values	Observed values	% Deviation
pH, Cl ⁻	1863.98	14.82	0.0134	Cl ⁻ = 1863.8-157.6 (EC)	1224.18	1462.6	19.47
pH, NO ₃ ⁻	-1.91	0.624	0.675	NO ₃ ⁻ = - 1.91+0.624 (pH)	2.95	3.58	21.35
pH, T-Ph	-0.75	0.407	0.596	T-Ph = - 0.75+0.407 (pH)	0.9024	1.08	19.6
Cl ⁻ , l-Ph	0.5339	0.0003	0.247	l-Ph=0.5339+0.0003 (Cl ⁻)	0.7391	0.69	7.1
Fl ⁻ , pH	0.169	0.145	0.924	l-Ph=0.169+0.1465 (Fl ⁻)	1.921	1.91	0.52

Table 6. Linear correlation and regression equation for some parameters and their predicted values (Ankleshwer)

Parameters	a	b	r	Regression equation	Predicted values	Observed values	% Deviation
SO ₄ ²⁻ , T-N	416.62	0.09	0.3485	T-N=0.09(SO ₄ ²⁻)+416.62	430.7	395	9.03
EC, Hard	-4157.4	1.842	0.5677	Hard=1.842(EC)-4157.4	1165.9	1250	7.2
COD, OM	-19.6	0.8235	0.942	OM = 0.8235(COD)-19.6	812.13	817	0.59
T-N, Ca ²⁺	31.11	0.5972	0.8380	Ca ²⁺ = 0.5972(T-N)+31.11	361.8	347	4.2
pH, Fe	34.53	20.32	0.2056	Fe=20.32(pH)+34.53	193.02	217	12.42

The linear regression analysis were carried out in few pair of water quality parameters. The result of regression analysis are summarised in Tables 5 and 6, presenting the value of correlation coefficient (r), emperical parameters a and b, linear regression equation, observed and predicted values for each pair.

CONCLUSION

The correlation and regression study of the physico-chemical parameters of industrial effluents reveals that all the parameters are more or less correlated with other. The linear correlation is very useful to get fairly accurate idea of the quality of the effluents experimentally and then predicting the remaining from such correlation.

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REFERENCES

1. Taylor K. et. Variation in seasonal precipitation chemistry with altitude in the northern Pennines. U.K. Env. Poll., **104**, 1 (1999).
2. Shrivastava, V. S. and Nemade P. N., Ground water pollution by industrial waste : A statistical approach. JIWWA, **29**,247(1997).
3. Tiwari, T. N. and Manzoor Ali. Correlation among water quality parameters of industrial wastes I : sugar industry. IJEP, **8**, 43 (1988).
4. APHA. Standards for the examination of water and wastewater (17th edn) American Public Health Association, Washington D.C. (1989).
5. Trivedy R.K. and Goel. P.K. Chemical and biological Methods for pollution studies. Environmental Publication Karad (1984).
6. Chakravarti, K. R., Singanan M. and Somshekhar Rao. A correlation study on physicochemical characteristics of paper mill effluent, Nazvid. IJEP., **16**, 46 (1996).
7. Kulkarni J.R. and Shrivastava V.S. Correlation and regression study of different physicochemical parameter of industrial waste water. IJEP., **21(2)**, 146 (2001).

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