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Original Article

Physico-chemical Characteristics of Industrial Wastewater samples and their Statistical Analysis

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Abstract:

The present communication deals with the physico-chemical Characteristics of Industrial Wastewater samples and their Statistical Analysis. Correlation and regression studies have been carried out among all possible pairs of 15 physicochemical parameters of industrial wastewater samples. The samples were collected from 10 different locations at MIDC, Jalgaon and analyzed for physicochemical parameters following standard methods. The values of some parameter like, Total Solids (TS), Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD), Sulphate (SO_4^{2-}), Chlorides (Cl^-) Total Phosphorus (TP), hardness were very high and found beyond the ISI permissible limits. It has been found that the value of correlation coefficient (r) lies between -0.821 to 0.999. The large positive correlation was observed between TS and TDS, TS and SO_4^{2-}, TDS and SO_4^{2-}, TDS and hardness, OM and COD, TP and Cl^-, SO_4^{2-} and hardness, NO_3-N and Ca, hardness and calcium. The results indicate that pH shows negative correlation with all other parameters. However, large negative correlation of pH was observed with TS (-0.803), TDS (-0.805), SO_4^{2-} (-0.821) and NO_3-N (-0.727). The linear regression analysis has been carried out for 10 pairs of parameters in which high correlation exists. It has been concluded that the systematic correlation and linear regression analysis provide excellent tool for rapid monitoring of pollution status and help us in understanding the relation between the physicochemical parameters and the interpretation of result

Key Words: *Pollution, Correlation, regression, Wastewater.*

Introduction:

Water is prime natural resource, a basic human need and precious national asset. Rapid urban population growth over the past few decades has introduced many important implications on the environment. Modern human society developed on the account of widespread industrialization triggered by the industrial revolution of the 18th century. But this is proving to be mixed blessing for mankind. Industries consume large quantities of water, consequently depleting the available resources and at the same time produce wastewater. The indiscriminate disposal of the wastewater into nearby water bodies or onto land is the main cause for the environmental pollution. The industrial wastewater contains toxic heavy metals and organic chemicals depending upon the various chemicals used in the industries. Disposal of the industrial waste causes toxic substances to be leached and seep in to the soil and affects ground water course (Khan and Khan 1983, Jain 2004, Reddy and Subba Rao 2001). Various industries like agrochemicals, paints, polymers, metal casting, hard board manufacturing and other small scale units are developed in MIDC Jalgaon. The effluent discharge from the industries even after anaerobic/aerobic treatment has several negative effects on environment. Therefore, regular monitoring of pollution parameters for industrial wastewater assumes paramount importance to maintain environmental safety. Also, chemical composition of industrial wastewater is very important deciding factor for treatment processes. However it is difficult to examine all the characteristics due to lengthy, time consuming and expensive procedures. But correlation study provides excellent tool for rapid monitoring of pollution status. By empirical relationship we can predict the value of one parameter on the basis of easily measurable parameter.

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A correlation study among groundwater quality parameters have been reported in literature (Rajasekaran *et al.*, 2004, Jain *et al.*, 2004, Nagarajan *et al.*, 1993, Kalvins *et al.*, 1996). Similar type of correlation study has been reported for industrial wastewaters (Tiwari and Ali 1988). The physicochemical parameters and their correlation regression analysis for the industries like textile, dyeing and printing, distillery, pulp and paper has been reported (Kulkarni and Shrivastava 2001, Nemade and Shrivastava 1997, Malaviya *et al.*, 2001). The objective of present investigation is to asses the industrial wastewater quality of MIDC, Jalgaon. The data collected from physicochemical analysis was evaluated statistically to found out the correlation among water quality parameters. The linear regression analysis has been carried out for the some pair of parameters.

Material and methods:

The industrial wastewater samples were collected from 10 different sites from MIDC, Jalgaon, samples were collected in plastic cans. The samples were brought to the laboratory and analyzed for water quality parameters. Determination of various physicochemical parameters like, pH, electrical conductivity (EC), total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), organic matter (OM), chemical oxygen demand (COD), total phosphate (TP), chlorides(Cl^-), sulphates (SO_4^{2-}), nitrate nitrogen(NO_3-N), hardness, calcium (Ca), magnesium (Mg), total nitrogen (TN) was carried out following standard methods(APHA 1985). The pH was measured by digital pH meter (Model Equiptronics EQ 610) and EC by pen type condutometer (Hanna instruments Maritius Ltd.). OM and COD were determined by dichromate oxidation method. Complexometric titrations were performed to find out hardness, Ca and Mg. Total phosphorus and nitrate nitrogen were determined spectrophotometrically by stannous chloride and phenol disulphonic acid method respectively. Chlorides were estimated by Mohr's method. The gravimetric method was used for sulphate estimation. All the reagents used for present work were AR grade. The results were subjected to descriptive and inferential statistics the statistical parameters like, mean (X), standard deviation (SD), standard error (SE), 95% confidence limit (95% CL), correlation coefficient (r) , empirical parameters 'a' and 'b' were calculated following literature method (Trivedy and Goel, 1984)

Results and discussion:

The physicochemical analysis of ten industrial wastewater samples from Jalgaon MIDC was carried out and presented in table 1. Descriptive statistics obtained for various physicochemical parameters of industrial wastewater are presented in table 2. It was observed that the pH values of the samples are in the range of 2.5-7.9. Three samples were found to be acidic while remaining were alkaline in nature. Electrical conductivity varies between 600-1980 µmhos/cm. The value of TS, TDS, TSS found to be in the range 2740-36520, 2660-35120, 80-2420 mg/l respectively. The values of TS for all the samples were found to be above the ISI permissible limits (2100 mg/l) and the values of TSS too, accept one sample for industrial discharge into surface water. The high value of these parameters imparts high COD, BOD and turbidity to the wastewater (Chakravarthi *et al.*, 1996). The high content of organic matter (462-2123 mg/l) responsible for high COD (681-2528 mg/l) because COD measures the non-biodegradable organic matter in biologically treated industrial effluents (Malaviya *et al.*, 2001) no doubt the oxidizable metal ions present in the samples also contribute to COD of the sample. The value of COD was also beyond the ISI permissible limit. Total nitrogen and total phosphorus found in the range 12-13-26.13 and 0.35-1.65 mg/l respectively. The value of Cl^- , SO_4^{2-} , and NO_3-N were lies between 99-5964, 1440-16328, and 52-154 mg/l respectively. Chloride content of 6 samples and sulphate for all the samples were above the ISI standards for discharge of industrial effluents into surface water. The high concentrations of Cl^-, SO_4^{2-}, and NO_3-N are due to the use of mineral acids for chemical processing in industries. Hardness was observed in the range 180-6800 mg/l. The concentration of cations like Ca and Mg varies between 64-1120 and 5-583 mg/l respectively.

The numerical values of correlation coefficient (r) are summarized in table 3. The value of correlation coefficient (r) for the physicochemical characteristics of industrial wastewater samples collected from MIDC, Jalgaon ranged between -0.821 to 0.999. It has been observed from correlation matrix that pH shows negative correlation with all other parameters. Total solids are positively correlated with total dissolved solids (0.999), sulphate (0.978), NO_3^- N (0.795) and hardness (0.844). Such high positive correlation of TS with above mentioned parameters indicates that, it might to be sufficient to determine total solids to get fairly accurate idea of other parameters. Similar linear relationship was observed between the pair of parameters like TDS and SO_4^{2-} (0.981) TDS and hardness (0.855), TP and Cl^- (0.782), NO_3N and Ca (0.867), hardness and Ca (0.878), OM and COD (0.989). These findings indicate that value of one parameter is largely dependent upon the other in which high correlation exists. High negative correlations were observed for pH with TS (-0.803), TDS (-0.805), SO_4^{2-}(-0.821), NO_3N (-0.727) and hardness (- 0.669). It suggests that the concentrations of the anions like SO_4^{2-} and NO_3-N are pH dependent. For highly acidic samples the concentration of SO_4^{2-} and NO_3-N should be higher this may be due to the presence of mineral acids like H_2SO_4 and HNO_3 or salts of these acids in the industrial wastewater. The linear regression analysis was carried out for 10 pairs of physicochemical parameters in which high correlation exist. The value empirical parameters 'a' and 'b', regression equation, observed and predicted value of the parameter and % deviation of predicted value from the observed value are presented in table 4. The concentrations of TS, TDS, OM, TP, SO_4^{2-}, NO_3-N, hardness have been predicted on the basis of regression

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equation and these values are in good agreement with observed values. This fact is also evident from small numerical value of % deviation between predicted and observed values.

Table 1: Physicochemical parameters for industrial wastewater samples.

Sr. No.	pH	EC	Total Solids	Total Dissolved Solids	Total Suspended Solids	Organic Matter (OM)	Total-nitrogen	COD	Total Phosphorus (TP)	Cl^-	SO_4^{2-}	NO_3-N	Hardness	Ca	Mg
1	7	1420	5680	4900	180	1596	25	1843	1.3	1945	2230	142	2320	838	56
2	7.1	1830	4340	2740	1600	638	23	760	0.7	916	2156	80	610	136	66
3	2.5	1540	33040	3060	2420	1118	26	1109	1.5	5964	13884	154	3500	980	143
4	3.4	1980	36520	35120	1400	1543	18	1697	1.4	1981	16328	116	6800	1120	583
5	9.5	1640	3620	2940	680	692	22	882	1.7	3053	2681	63	1300	385	37
6	7.5	600	3060	2700	360	462	12	681	0.4	1100	2650	54	1620	273	107
7	7.5	1630	2740	2660	80	905	16	1045	0.5	575	1440	52	180	64	5
8	7.4	1740	3690	3280	410	1472	19	1753	1.7	4011	4584	90	2910	858	508
9	7.9	1840	5250	4620	630	2123	15	2528	0.9	781	4279	110	1360	419	158
10	4.3	1110	3480	3340	140	1834	17	2184	0.8	99	4427	97	1840	589	244

EC – Electrical Conductivity, TS - Total Solids, TDS - Total Dissolved Solids,
TSS - Total Suspended Solids, OM - Organic Matter, TN - Total Nitrogen,
COD - Chemical Oxygen Demand, TP - Total Phosphorus
All the concentrations are expressed in mg/l except pH and EC (mho cm-1)

Table 2. Statistical parameters for industrial wastewater samples.

Parameters	Minimum	Maximum	Average	Std. Dev.	Std. Error	95%CL
pH	2.5	7.9	6.42	2.24	0.71	6.42 ±1.60
EC	600	1980	1533	409	1.229	1533 ±2.78
TS	2740	36520	10142	13043	4125	10142 ± 9322
TDS	2660	35120	9292	12496	3952	9292 ±8931
TSS	80	2420	850	741	234	850 ±530
OM	462	2123	1238	558	176	1238±399
T-N	12.13	26.13	1926	4.4292	1.4	1926±3.164
COD	681	2528	1448	639	202	1448 ±456
TP	0.35	1.65	1.045	0.4935	0.156	1.045±0.35
Cl^-	99	5964	2043	1825	577	2043 ±1304
SO_4^{2-}	1440	16328	5466	5222	1651	5466 ±3730
NO_3-N	52	154	101	41.4	13	101±29.58
Hardness	180	6800	2244	1884	596	2244 ±1346
Ca	64	1120	566	367	116	566 ±263
Mg	5	583	191	200	63	191±143

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Table 3. Correlation matrix for physico-chemical parameters of industrial wastewater samples.

Parameters	pH	EC	TS	TDS	TSS	OM	T-N	COD	TP	Cl^-	SO_4^{2-}	NO_3-N	Hard	Ca	Mg
pH	1														
EC	-0.03	1													
TS	-0.803	0.331	1												
TDS	-0.805	0.324	0.999	1											
TSS	-0.568	0.364	0.751	0.725	1										
OM	-0.294	0.301	0.136	0.15	-0.131	1									
T-N	-0.261	0.372	0.334	0.308	0.688	-0.022	1								
COD	-0.185	0.237	0.013	0.028	-0.246	0.989	-0.116	1							
TP	-0.14	0.465	0.418	0.414	0.381	0.222	0.615	0.163	1						
Cl^-	-0.304	0.203	0.525	0.512	0.616	-0.109	0.622	-0.196	0.782	1					
SO_4^{2-}	-0.821	0.319	0.978	0.981	0.668	0.24	0.237	0.13	0.451	0.512	1				
NO_3-N	-0.727	0.366	0.795	0.793	0.627	0.564	0.501	0.46	0.502	0.406	0.785	1			
Hardness	-0.669	0.269	0.844	0.855	0.437	0.324	0.149	0.245	0.527	0.399	0.89	0.788	1		
Ca	-0.652	0.224	0.719	0.725	0.433	0.499	0.412	0.415	0.719	0.595	0.769	0.867	0.878	1	
Mg	-0.443	0.312	0.482	0.499	0.072	0.438	-0.142	0.411	0.426	0.213	0.62	0.469	0.803	0.694	1

Table 4. Regression analysis for some selected parameters of industrial wastewater samples.

Parameters	a	b	r	Regression equation	Predicted	Observed	%deviation
TS,TDS	450.65	1.043	0.999	TS=450.65+1.0429 (TDS)	5268	5250	0.34
TS,SO_4^{2-}	-3203.3	2.442	0.978	TS=-3203.31+2.4415 (SO_4^{2-})	36661	36520	0.38
TDS, SO_4^{2-}	-3535	2.347	0.981	TDS=-3535+2.3467 (SO_4^{2-})	2683	2700	-0.62
TDS, Hardness	-3436.1	5.672	0.855	TDS=-3436.1+5.672 (Hardness)	35134	35120	0.03
OM, COD	-11.72	0.863	0.989	OM=-11.72+0.8631 (COD)	644	638	0.93
TP, Cl^-	0.6128	2E-04	0.782	TP= 0.6128 +0.0002 (Cl^-)	1.45	1.65	-13.8
SO_4^{2-}, Hardness	-70.491	2.467	0.89	SO_4^{2-} = -70.491 + 2.4671 (Hardness)	4469	4427	0.94
NO_3-N, Ca	45.469	0.098	0.867	NO_3-N = 45.469 + 0.0977 (Ca)	51.72	52	-0.54
Hardness, Ca	-305.67	4.503	0.878	Hardness = -305.67+4.5031 (Ca)	1428	1300	9.84
SO_4^{2-}, pH	17717	-1908	-0.82	SO_4^{2-} = 17717-1908.35 (pH)	12946	13884	-6.76

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Conclusion:

On the basis of the results, following conclusions have been drawn. Total solids are positively correlated with, TDS, SO_4^{2-}, NO_3-N and hardness. Thus, the value of these parameters can be predicted readily by determination of TS only. Similarly TDS measurement gives fairly accurate idea of SO_4^{2-} and hardness. The negative correlation of pH was observed with TS, TDS, SO_4^{2-}, NO_3-N and hardness, indicating that increase in pH of the sample is associated with decrease in the concentration of the parameters which are negatively correlated. Finally, it has been concluded that, correlation and regression analysis among physicochemical parameter is excellent tool for rapid and periodic monitoring of industrial wastewater. However, this tool is useful only for specific environmental conditions where the quality and quantity of the effluent do not change drastically.

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