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Correlation & regression among the parameters of industrial effluents of U.P. India

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Abstract
In the present investigation the data collected on the physico-chemical characteristics of the industrial effluent have been analyzed for correlation and regression among the various parameters *viz*., pH, TS, TDS, TSS, COD, BOD, Acidity Hardness, Cl, SO_4, Ca, Mg, Na, K, etc. This industry is located at Rampur Distt. U.P. in India, for these studies a wizard fast digital computer unit was used. Beside the above analysis standard deviation, relative standard deviation and coefficient of variation in all the parameters have also been evaluated, respectively.

Keywords: Industrial waste, regression, correlation coefficient

Introduction
Industrial effluent is generated from a wide variety of production and processing processes. Depending on the industry, industrial effluent can be composed of various components. Besides organic compounds like oil fat, alcohol and flavorings, other substances such as heavy metals, acid and alkalis also combine with the water. This kind of effluent must be pretreated before discharging it to public sewage treatment plants or nature or reusing it for internal purposes. Rampur distillery Ltd. Rampur (U.P.) India effluent is one of the major waste of ecological concern; the plant is situated 65 Kms. west of Bareilly and manufacturing ethyl alcohol in different grade of applications. In the present work the quality of industrial effluent is described according to the correlation and regression of its physico-chemical parameters [1-3]. Several workers have carried out similar work [4-6] for water quality parameters.

Materials and Methods
All chemicals and reagents for this research work used were of AR grade. Industrial waste water samples were collected from Rampur distillery Ltd. Rampur (U.P.) India unit at monthly intervals from August 2021 to Mer 2022. The samples were analyzed for the physico-chemical parameters by following standard methods [7]. Standard deviation, relative standard deviation and coefficient of variation were calculated for various parameters [11].

Results and Discussion
All results are shown in Table (1-4). Table-1 reveals that average, standard variation (SD), relative Standard deviation (RSD) and coefficient of variation (CV) values of the parameters analyzed for industrial waste-water exhibit a declining effect. An attempt has also been made to explain the variation by Fig. 1 below the Table 1. Table 2 and 3 demonstrated by correlation coefficient (r) and coefficient of linear regression A and B. The statistical data of the correlation coefficient between each pair of industrial effluent parameters have been presented in Table-2 and in Fig. 2 as well. To carry out these extensive numerical calculations a brief-details are mentioned below the tables.

Table 1: Average values of physico-chemical analysis of industrial effluent.

Parameters	No. of Sample	Average Value	± SD	RSD	CV%
pH	8	4.1	0.321	0.0711	7.123
TSS mg/l	8	22.93	508.31	0.185	20.24
TDS mg/l	8	60410	3315.12	0.0483	5.112
TS mg/l	8	62631	3298.34	0.555	5.498
COD mg/l	8	74003	3020.14	0.0398	4.015
BOD mg/l	8	1245	398.2	0.071	7.812
Acidity mg/l	8	10223	301.12	0.038	3.101
Cl mg/l	8	6350	710.12	0.115	11.123
SO_4 mg/l	8	4129	430.1	0.117	10.507
Hardness mg/l	8	7900	740.63	0.098	9.733
Na mg/l	8	309	38.07	0.129	12.112
K mg/l	8	10980	962.28	0.081	8.441
Ca mg/l	8	1582	399.23	0.242	2.492
Mg mg/l	8	1044	325.55	0.311	3.068

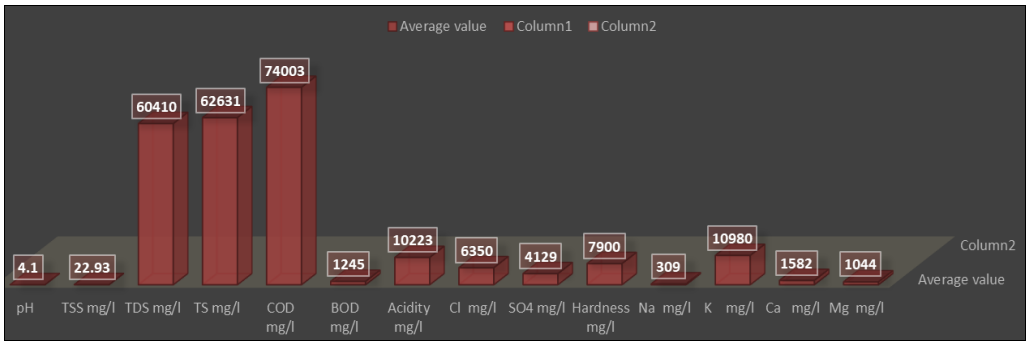

Fig 1: Diagram showing average value of parameters (Industrial effluent)

Table 2: Correlation coefficients values for industrial effluent at different parameters

Parameter	pH	TSS	TDS	TS	COD	BOD	Acidity	Cl	SO_4	Hardness	Na	K	Ca	Mg
pH	1.00	0.25	0.25	0.13	-0.53	-0.50	-0.96	-0.41	0.02	0.32	0.05	0.42	-0.16	0.33
TSS		1.00	0.96	0.72	0.22	0.23	-0.31	-0.63	0.46	-0.55	0.03	-0.43	-065	-0.14
TDS			1.00	0.70	0.25	0.26	-0.32	-0.61	0.49	0.51	-0.25	0.42	-0.76	-0.17
TS				1.00	0.02	-0.19	-0.16	0.63	-0.02	0.72	-0.76	-0.72	0.13	0.03
COD					1.00	0.21	0.50	0.04	0.56	-0.13	0.17	-0.32	-0.54	-0.17
BOD						1.00	0.30	0.44	0.01	-0.28	-0.04	-0.36	-0.20	-0.39
Acidity							1.00	0.35	0.11	0.29	0.65	0.32	0.39	-0.19
Cl								1.00	0.12	0.13	0.34	0.17	-0.82	0.05
SO_4									1.00	0.12	0.64	0.44	0.04	0.39
Hardness										1.00	0.52	0.72	-0.26	-0.26
Na											1.00	0.57	0.02	0.16
K												1.00	0.15	0.13
Ca													1.00	0.11
Mg														1.00

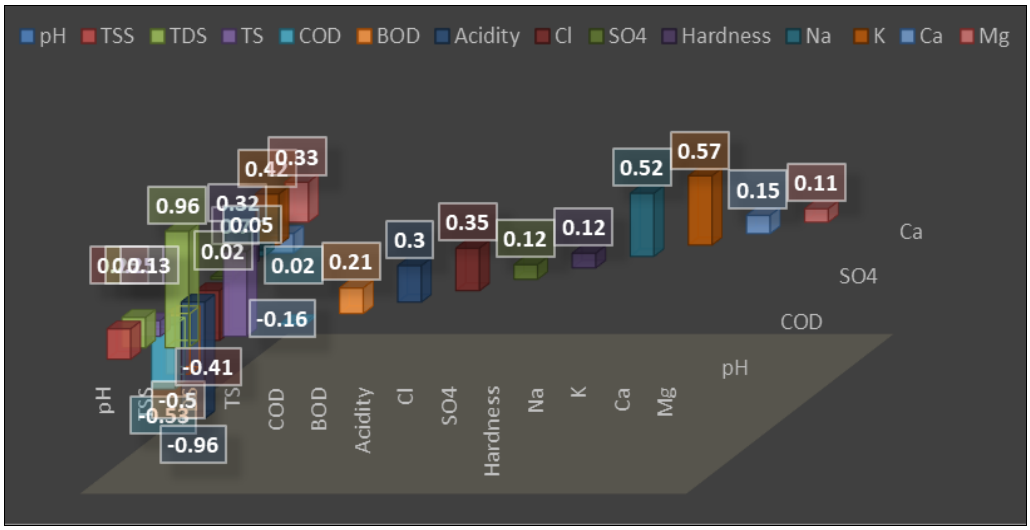

Fig 2: Showing Correlation coefficients values at diff. parameters

Table 3: Least square fitting for linear relations parameters for industrial effluent

X		Y	r	A	B
1.	pH	Acidity	-0.9 7	-1221.51	11312.04
2.	TSS	Cl	-0.72	-1.063	7954.94
	TSS	Hardness	-0.75	-1.120	10339.33
	TSS	Ca	-0.75	-0.698	3143.08
	TSS	Mg	-0.70	-0.418	1798.89
3.	TDS	TSS	0.70	-0.079	3107.51
	TDS	Cl	-0.61	-0.26	12545.86
	TDS	Na	-0.72	-6.604	598.92
4.	TS	TSS	0.96	1.029	-5023
	TS	TSS	0.96	0.068	-4076.07
	TS	Cl	0.75	-0.168	15020.70
	TS	Na	-0.63	-6.502	410246.29
5.	Cl	Ca	0.60	0.298	-151.67
6.	SO_4	Na	-0.82	-0.079	475.37
7.	Hardness	Ca	0.60	0.414	-1381.14
8.	Hardness	Mg	0.93	0.329	-1693.51
	Ca	Mg	0.71	0.453	146.762

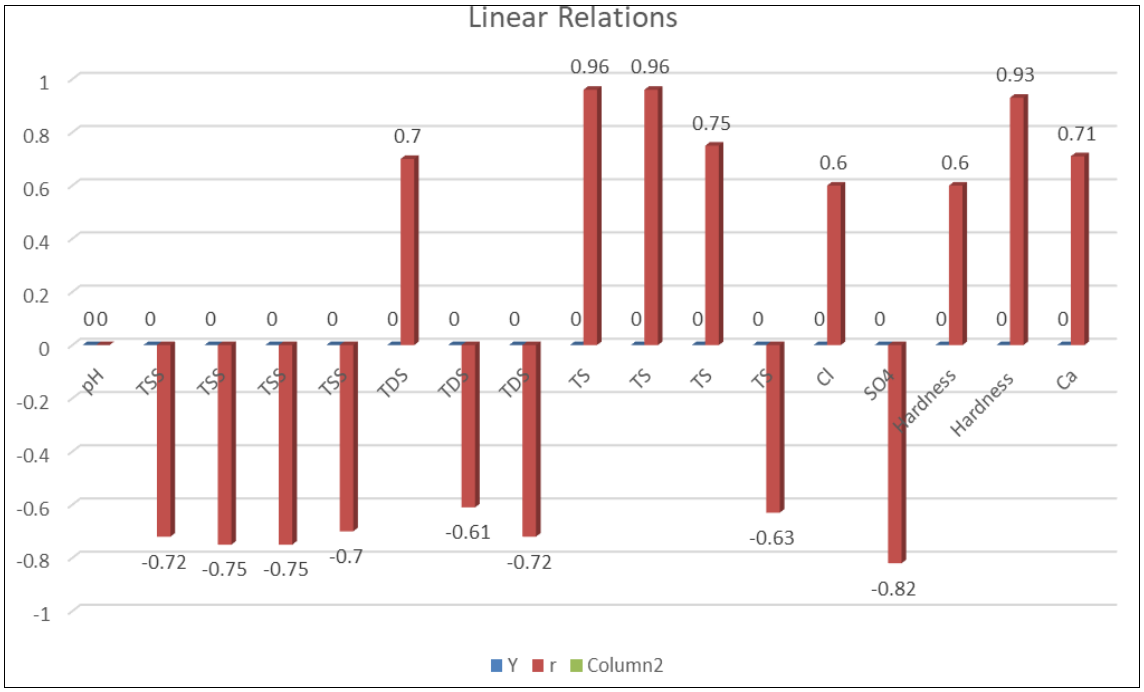

Fig 3: Bar diagram showing linear relationship

Correlation and regression are techniques used to analyze the relationship between two quantitative variables, while correlation measures the strength of a linear relationship between two variables, regression measures how these variables affect each other using an equation. X & Y are the two variable, r-Correlation coefficient has been calculated between each pair of 14 industrial waste water parameters by using the experimental data A & B are the constant

$$r = \frac{\sum xy}{(\sum X^2)(\sum Y^2)} \qquad x = X - \overline{X}$$

$$y = Y - \overline{Y}$$

For higher value of r between X & Y their linear relation will be

$$Y = Ax + B$$

On the basis of above A & B can be calculated

$$Y - \overline{Y} = r\frac{6Y}{6X}(X - \overline{X})$$

Where

$$\overline{X} = \frac{\sum X}{n}, \qquad \overline{Y} = \frac{\sum Y}{n}$$

6Y- Standard deviation of Y

6X- Standard deviation of X
n= no. of observation

All data were run on the digital computer in the dept. of chemistry Bareilly College, Bareilly. In the present work most of the observation of pH values was found to be (+ve)

between TSS, TDS, TS, Hardness, K, Ca, and Mg etc., whereas most (-ve) values of TSS was observed against the parameters COD, BOD, Acidity, Cl, SO_4, hardness, Na, Ca and Mg etc. The values of R in positive correlation lie between +0.01 to +0.99 and in case of negative correlation -0.02 to -0.99. The high (+ve) correlation value (0.99) was observed in between pH and acidity. The low (+ve) correlation value (0.01) was observed in between BOD and Cl whereas negative (-0.02) value was observed in between TSS and COD, TS & Cl, Na & K, respectively [11]. The value of r in the case of positive correlation nearer to +1 or in the case of negative correlation nearer -1 show that the greater probability of a definite linear relationship exists between the variable of parameters (e.g. X & Y). The values of r that tend towards zero indicate that the pair of parameters are not linearly related [9].

The values of linear relation have been shown in table 3 and also discussed in diagram in fig. 3. Again, to save space we have presented the results only for those parameters which have $r \geq \pm 0.60$ to ± 0.99, although we have calculated the value of A & B for each possible pair of 14 parameters [10]. When A & B have been determined the linear relation of the type given equation (y=Ax + B) can be used to predict the value of industrial waste water quality parameters Y, when the values of the parameter X is measured experimentally. With the help of the above linear equation we have predicted the values of TSS and Cl from the experimentally measured values of TDS. The results of the predicted and observed values of TSS and Cl are being given in table 4.

The above findings show that many such positive and negative correlations do exist among these parameters. The very high positive value of r^2 shows that the variation of Y is influenced by changes of X. The high positive values of coefficient of determination (r^2=0.98) of a pair pH and acidity reveals that 98% variations in acidity values are influenced by pH changes. However, the possibility of resting 2% can be attributed to other causes. So our task is not only important for environmental scientists but also to the engineer's working on industrial management and research in this area.

Table 4: Predicted and Observed values of TSS and chloride as functions of TDS

TDS mg/l	TSS mg/l		Cl mg/l	
	P	O	P	O
53810	1650	1815	5510	6590
55986	2005	2373	6101	6001
54989	1333	1392	6173	6338
57993	2030	2183	5883	6173
58896	2210	2432	5633	4325
63976	2608	2653	6082	5392
60999	2328	23869	5483	5782
58896	2134	2005	5782	5906

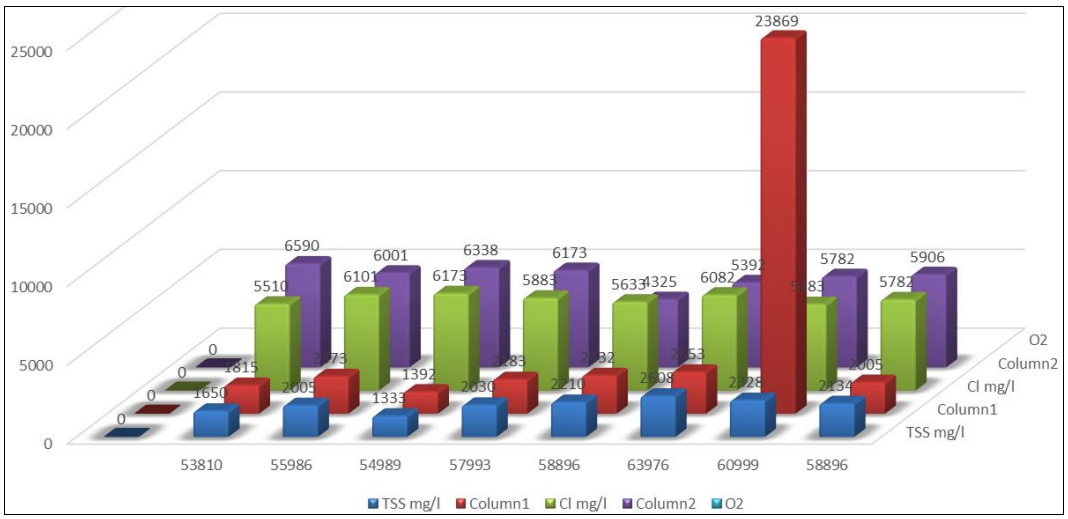

Fig 4: Showing predicted and observed values of different parameters

Conclusion

This study will provide a baseline data and help to delineate the physico-chemical characteristics of industrial effluent and correlation between them. We concluded that above data is also showing that industrial effluent is not suitable for vegetables, plants and soil. It may be suitable for some crops after 50% dilution.

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