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Analysis of Residuals for the Elimination of total Suspended Solids Simulation of wastewater through Rotating Biological Contactor

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Abstract: Increased attention towards substitute water resources has become unavoidable, as the world's freshwater supply becomes gradually scarcer. Reuse of Greywater is a hopeful alternative water source for non-potable uses, which could be exploited on a continuous basis and treated. Getting average removal% of Total Suspended Solids from greywater through Rotating Biological Contactor following experiment was conducted to evaluate the significance Hydraulic Retention Time with numbers of discs.

Consequences reveal that linear as well as quadratic estimate of HRT and number of discs have are highly significant effect as their corresponding p-values are even less than 0.01.By using coefficients of the table the regression equation is Removal = Removal% = -26.74 + 20.14 Time + 1.253 Disc, where the sample standard deviation is 4.82. Lack of fit of the equation is insignificant i.e. 0.155, which implies that the regression equation is fit for prediction. The probability plot of the residuals is roughly straight which demonstrate that errors distributions are around normal. Furthermore, Residual plot shows the linearity assumption appear to be met with constant standard deviations. Histogram of Residuals make obvious normality assumptions as the plot resembles an example of a sample from a normal distribution centered at zero and normally and independently distributed NID (0, σ^2) assumptions on errors are accomplished as standardized residuals are approximately normal with mean zero and unit variance.

Keywords: Residual Analysis, Total Suspended Solids, Regression, Response Surface Modeling, Hydraulic Retention Time

1. INTRODUCTION

Water is life and in the populous countries fresh water resources are under massive stress. In the coming years Pakistan is also probable to have a large population growth and the significance of fresh water can never be denied. when per person per year water requirements drop under 1000 cubic meters, such state or country is said to be water stressed affirmed by Falkenmark and Lindh. (Garfin *et al.* 2014) affirmed that higher demands for freshwater supplies is the result of over increasing populations, in more recurrent and severe droughts are probable to result as change of climate that will place further stress on previously over used water resources. In order to protect the world's most priceless asset this can be handled by using water protecting techniques such as low-flow fixtures, appliances and new methods are required to move toward their maximum water saving potential. Since a reliable source of water, reclaim of recycled Greywater, in current time is receiving amounting consciousness. According to Ali, Hafiz Qasim countries like Saudi Arabia, Singapore Jordan and other are regaining the recycled Greywater and for getting extensive development keep it in their national policies.

According to (Jillian 2014) rather than an increased freshwater supply, reuse of reclaimed and Greywater are effective options to costly, complex and large developments by relying on a reduced demand of freshwater. Greywater is defined as "raw wastewater is defined as Greywater not including toilet and in most cases kitchen sink and dishwasher wastewaters. (Yu, *et al.* 2013) stated that many descriptions eliminate kitchen wastewaters from the dishwasher and kitchen sink; though there are some studies and state parameters that distinguish light and dark (as well as kitchen outflow) Greywater from one another.(Sheikh, 2010) demonstrated that reuse of reclaimed water and Greywater are also helpful means of protecting the recourses of freshwater. The objective of Greywater treatment in general is to decrease the microorganism, organic content, suspended solids and the concentrations present in the raw Greywater as stated by (Sharvelle *et al.* 2013).

The Rotating Biological Contactor(RBC) is an appropriate efficient Technology in all areas, as there exists has a worldwide requirement for economical wastewater treatment.(Pathan, *et al* 2015) demonstrated that RBC unit holds a series of discs connected to a regular shaft. The series of discs are moderately submerged in a channel of continuously flowing wastewater. With the rotating of discs, a film of microorganisms raze on the discs devour oxygen from the air and organic material. In this way, from the wastewater substrate is removed.

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Analysis of Regression, further exclusively assists to recognize that featured variable values according to the adjust factors or criteria when any one of a variety of variable in the meantime as other free factors that are made stable, stated by Doudpoto *et al.* (2017). According to Jacobcohen *et al.* (2003) for approximation the association is surrounded by a variable, Analysis of Regression is a statistical technique which will contain methods for modeling and analysis of numerous factors when the focal point of consideration lies in collaboration among variable and one or more independent variables.

(Raymond *et al* 2016) stated that when the purpose is to optimize the outcome of study, Response surface methodology (RSM) is a set of statistical and mathematical procedure supportive for the analysis, modeling and for problems in which a response of interest is influenced by a number of variables. (Aziz *et al* 2007) concluded that to optimize different biotechnological and chemical processes, RSM is a group of statistical and mathematical procedures broadly used to conclude the effects of numerous variables.

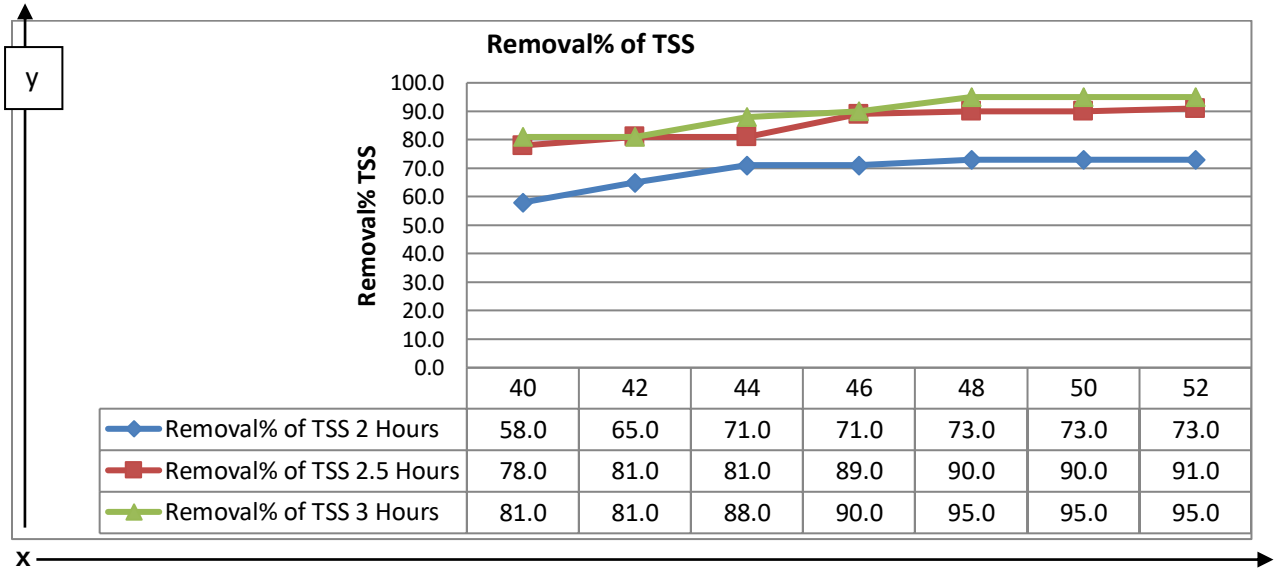
Residual analysis is a method which facilitates to decide whether it is practical to expect that assumptions are met or not, as between the observed and predicted values the differences are shown by the residual analysis. According to (Weiss 2017) inferences are met by three circumstances in multiple regression, adjacent to each predicted variable, the residual plotcentered about the horizontal axis and should fall just about in a horizontal band symmetric, against predicted y-values, the residual plot should fall just about in a horizontal band symmetric and the normal probability plot of the residuals should be approximately linear.

To check normality assumptions are met or not, Histogram of Residuals can also be made stated by Raymond *et al.* (2016). (Douglas 2005) affirmed that if normally and independently distributed assumptions NID (0, σ^2) on errors are satisfied, the plot looks like a sample from a normal distribution centered at zero.

2. MATERIALS AND METHODS

Due to a decreasing freshwater supply and increasing populations alternatives for freshwater maintenance are in high demand. Over the removal of Total Suspended Solids (TSS) taken from RBC, Regression Analysis is applied. From Hostel of Sindh University principal information regarding quantities of TSS and associated information of grey water were composed after processed into RBC. To fit the quadratic response two factors were chosen i.e. Hydraulic Retention Time (HRT) and Number of Discs to analyze the effect for the present study. In order to optimize the removal response through RBC different procedures were applied i.e. multiple numbers of discs 40, 42, 44, 46, 48, 50 and 52 with different HRTs i.e. 2, 2.5 and 3 hours for Greywater treatment.

To illustrate residual plots and 3D plots Origin pro version 7 and for analysis Minitab: 17, Statistical software for Social Sciences (SPSS: 20) and Ms Excel are used. The expanded statistical model authenticated with the preceding investigational work by the researchers.



	40	42	44	46	48	50	52
Removal% of TSS 2 Hours	58.0	65.0	71.0	71.0	73.0	73.0	73.0
Removal% of TSS 2.5 Hours	78.0	81.0	81.0	89.0	90.0	90.0	91.0
Removal% of TSS 3 Hours	81.0	81.0	88.0	90.0	95.0	95.0	95.0

Fig. 1:Average removal of TSS on different HRTs levels i-e; 2 hours, 2.5 hours and 3 hours with multiple numbers of discs

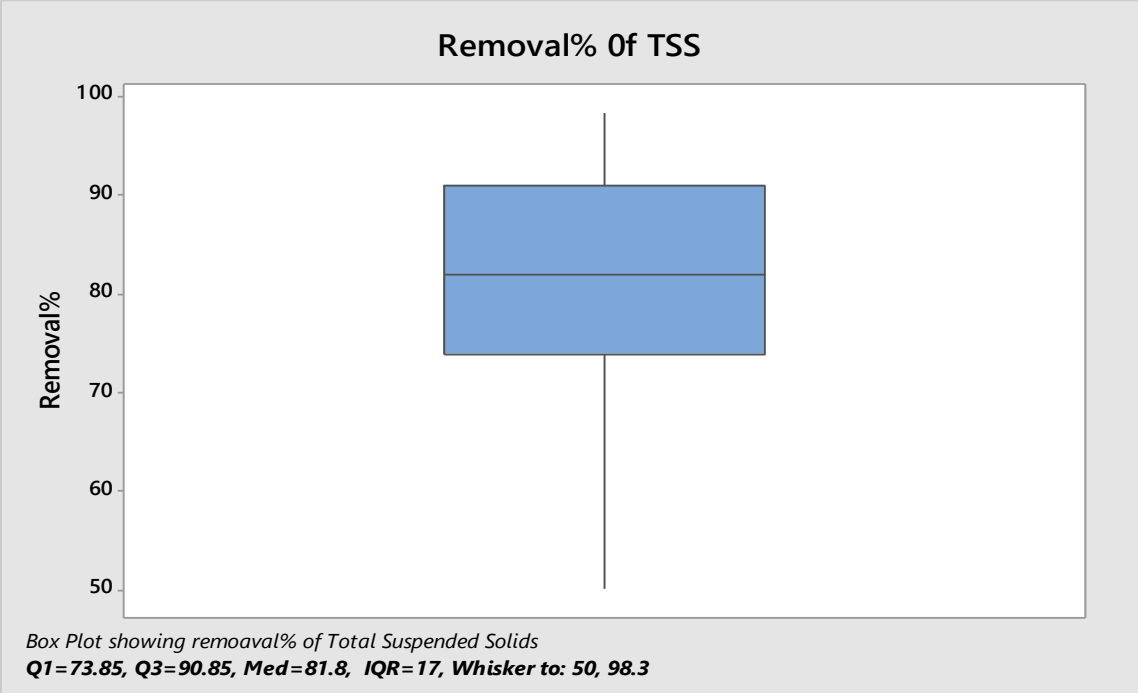


Fig. 2: Whisker Box Plot showing Removal% of TSS on 2, 2.5 and 3 Hours HRTs with different descriptive measures

A number of HRTs levels i-e; 2 hours, 2.5 hours and 3 hours and various numbers of discs of average removal% of TSS with corresponding area increment are shown in **(Fig. 1)**. The removal% is improved simultaneously, as the HRT and Number of discs is increased. Descriptive statistics including Quartiles Q_1= 73.85 and Q_3= 90.85, Median= 81.8, Inter Quartile Range= 17.0 and whisker observations i.e. 50.0 to 98.3 of the average removal% of TSS are symbolizing in **(Fig. 2).** The effect of 3D Response Surface regarding HRT and Number of Discs on Removal of TSS is shown in **(Fig.3-4).**

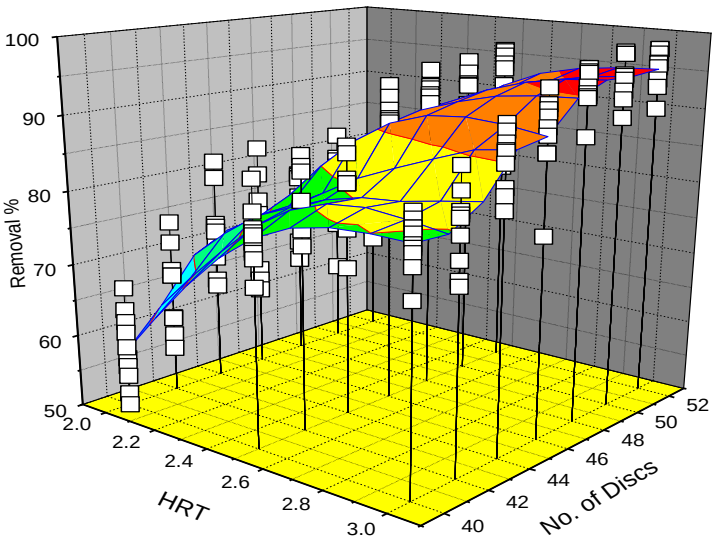


Fig. 3: RSM 3D Model for TSS

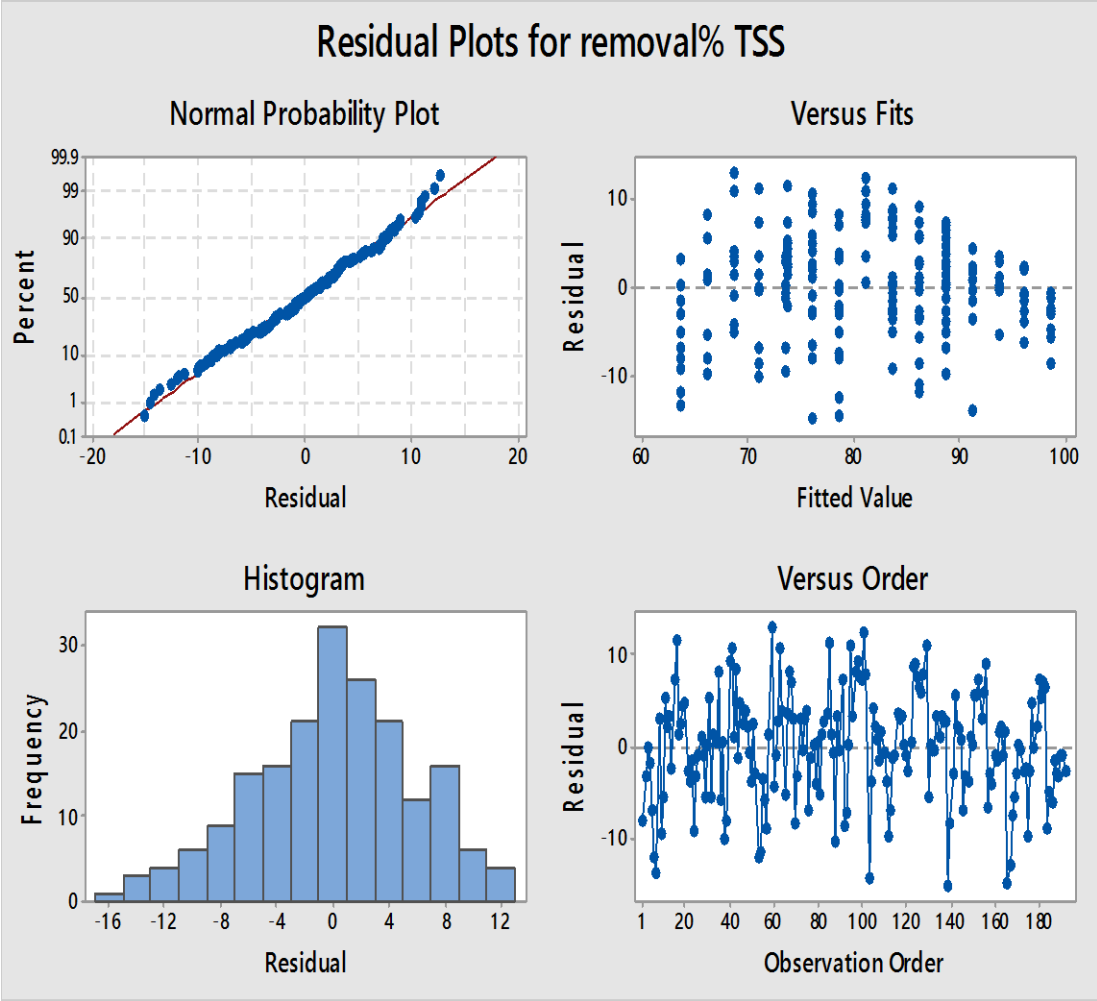


Fig.4: Normal Probability, Fits, Histogram residual Predicted (Fitted) values of removal of TSS.

Table 1: Table represents Predictor variables, coefficients as well as their consequent t and p values for Response Surface Model.

Predictor	Coefficient	Standard Coefficient	t-values	p-values (sig.level)
Constant	-370.3	60.5	-6.12	0.000
Time	137.2	17.7	7.75	0.000
Disc	10.90	2.35	4.29	0.000
time^2	-25.22	2.96	-8.53	0.000
Disc^2	-0.1015	0.0249	-4.07	0.000
Time disc	0.196	0.211	0.93	0.354

Table 2: Table containing t and p-values showing the effect of intercept, retention time and number of discs on the removal of TSS

Predictor	Coefficient	Standard Deviation	t-values	P- values
Constant	-26.74	5.45	-4.90	0.000
Time	20.14	1.03	19.52	0.000
Disc	1.253	0.104	12.01	0.000

The regression equation is

Removal% = -26.74 + 20.14 Time + 1.253 Disc

Table 3: ANOVA table Containing F and P-values showing the effect of the removal of TSS

Source	DF	SS	MS	F	P
Regression	5	19987.4	3997.49	171.62	0.000
Time	1	1399.9	1399.89	60.10	0.000
No. of Discs	1	428.1	428.08	18.38	0.000
Time^2	1	1695.5	1695.54	72.79	0.000
Disc^2	1	385.9	385.87	16.57	0.000
TimeDisc	1	20.1	20.14	0.86	0.354
Error	186	4332.4	23.29		
Lack of Fit	15	472.0	31.47	1.39	0.155
Pure Error	171	3860.4	22.58		
Total	191	24319.8			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
4.82621	82.19%	81.71%	81.05%

3. RESULTS AND DISCUSSION

To predict and forecast a number of applications, Regression is used widely by function and to comprehend the associations among the variables and arguments connecting to study. For this study fact through RBC regarding the removal% of TSS was collected from the Hostels of Sindh University by different measures pertaining to the multiple numbers of discs, and the HRT. With their subsequent "t" and "p" values in table no. 1, the coefficients of the above equation are specified indicates that linear as well as quadratic estimate of HRT and number of discs are highly significant as their p-values are even under 0.01, as literature revealed that a factor possesses p-value less than 0.05 is considered as significant. However, Interactive impact of HRT and number of discs is found to be insignificant as its p-value is greater than 0.05 i.e. 0.354.

(Table 2) reveals that on the removal of TSS even significance level was 0.05, estimate of HRT and number of discs has extremely significant effect, as their consequential p-values are less than 0.01. Using through coefficients of the table the regression equation is Removal = -26.74 + 20.14 Time + 1.253 Disc. Furthermore, ANOVA in **(Table 3)** authenticate the obtained consequences.

The distributions of errors are around ordinary in Normal Probability Plot. Furthermore the normal probability plot of the residuals is found to be roughly linear. Propensity of normal probability plot upward somewhat slightly on right side and to curl down slightly left side suggests that the tails of error distribution are somewhat more slender than would be expected in a normal distribution.

Between the observed and predicted values the variations are illustrated by Residual analysis. The linearity assumptions and constant standard deviations appear to be met are affirmed by Residual plot. In Figure 4 Histogram of residuals illustrating normally and independently distributed NID (0, σ^2) supposition on errors are fulfilled as consistent residuals are just about normal with mean zero and unit variance and normality assumptions as the plot resembles an example from a normal distribution centered at zero.

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