"Modeling of Pollutant Removal Using Sewage Treatment Plant"

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Abstract- *Water is essential and most available resource for every aspect of environment yet we have limited resource of it. The increase in population along with increase in urbanization-industrialization resulted in increased water pollution reducing fresh water availability. The waste water produced by different sector of economy contains different types of pollutants(Suspended solids, Dissolved solids, heavy metals, organic pollutants etc.).The treatment of this wastewater, its costs are growing areas of concern. Many conventional methods are used to remove this pollutants but one need to increase the efficiency of treatment process to increase the quality of treated water. Thus many statistical approaches have been developed in order to increase the pollutant removal efficiency of treatment process. This paper reviews the results of application of one of this statistical approach i.e. Response surface methodology for removal of pollutant from wastewater by citing several journals.*

Keywords- Wastewater, Response surface methodology

I. INTRODUCTION

Different sector of society generates different types of wastes which are disposed in water resulting in increase in amount of waste water.Approximately two-thirds of the population in the developing world has no hygienic means of disposing excreta and an even greater number lack adequate means of disposing of total wastewater (Rose, 1999). Main concern is treatment of industrial effluents .The effluent from industry contains high amount of COD, Total suspended solids, strong color, variable pH, heavy metal. Continuous use of sewage water leads to accumulation of heavy metals and pathogenic micro-organism in the soil as well as in the plants (Rose, 1999). If this effluent enters in environment it may lead to irreparable harm to every aspect of it.The greatest challenge in the water and sanitation sector over the next two decades will be the implementation of low cost sewage treatment which will permit selective reuse of treated effluents for agricultural and industrial purposes (Looker, 1998).Innovative and appropriate technologies can contribute to urban wastewater treatment and its reuse (Mourad, 2011). Many conventional methods are used to remove this pollutants but one need to increase the efficiency of treatment process to increase the quality of treated water. Thus many statistical approaches have been developed in order to increase the pollutant removal efficiency of treatment process. Response surface methodology (RSM) is one of such statistical approach.

Response surface methodology (RSM) is an experimental strategy introduced by George E.P. Box and K. B. Wilson in year 1951. RSM use the sequence of designed experiments to obtain an optimal response. Box and Wilson used a second-degree polynomial model to do this. Howeverthey acknowledged that this model is an approximation, but they use it because this model is easy to estimate and apply, even when little is known about the process.RSM can be used to maximize the production of a special substance by optimizing operational factors.The choice of design depends on the properties required.

Response surface methodology (RSM) is collection of group of mathematical and statistical techniques. It includes modeling of a response function, corresponding choice of design, and determination of optimum conditions. Response Surface Methodology along with reasonable experimental designs is used to establish functional relationship between responses and factors and to obtain polynomial quadratic regression equations which are analyzed to obtain optimal process parameters and to predict responses.

Its greatest applications have been in industrial research, particularly in situations where most of variables influencing the system feature (Myers and Monntgomery, 2002). The Box- Behnken design optimizes the amount of experiments to be applied to establish the possible interactions between the parameters studied and their effects on the absorption of NO. Box–Behnken design is a spherical, revolving design; it consists of a central point and the middle points of the edges of the cube circumscribed on the sphere (Aslan and Cebeci, 2007).

Hill and Hunter define four steps for response surface analysis (Myers, Khuri, and Carter 1989).

They are

1) perform a statistically designed experiment,
2) estimate the coefficients within the response surface equation,
3) Adequacy of the equation is checked using lack of fit test
4) study the response surface within the region of interest.

II. LITERATURE STUDY

M. Mourabet et al.(2014) conducted study on " Use of response surface methodology for optimization of fluoride adsorption in an aqueous solution by Brushite".Author used Response surface methodology (RSM) for the removal of fluoride on Brushite by optimizing process parameters .Statistical Box–Behnken design was used to obtain the best response of fluoride removal. Four important process parameters were optimized. Analysis of variance (ANOVA) was used to analyze the experimental data which was fitted to a second-order polynomial equation using multiple regression analysis. Optimum conditions for removal of fluoride(maixmum) was identified by using Numerical optimization and applying desirability function. 88.78 % of fluoride removal was achieved under this selected optimized condition.

Ghanim(2014) worked on "Optimization of Pollutants Removal from Textile Wastewater by Electro coagulation through RSM". Author optimized previous experimental data of textile effluent by applying response surface methodology (RSM). Author developed central composite design (CCD) for removal of each parameters (COD, Total Suspended Solid and turbidity) for adequate and reliable measurements mathematical quadratic polynomial models of response surface. Author developed response surface models were developed with values of correlation coefficient *R2* equals 0.9946 for COS, 0.9941 for TSS and 0.9876 for Turbidity removals. As evident from the very low probability values of regressions the ANOVA on these models showed that the models prepared were highly significant. In order to find out the optimum zones of pollutants removal author prepared graphs of 2-D contour & 3-D response, removal efficiency explained by regression models was optimized in order to find maximum levels .Maximum responses of 85.7538 for COD, 83.0554 for TSS and 92.0225 for turbidity removal were predicted with operation time and current density of (56.54 min. & 20mA/cm2), (53.13 min. & 20 mA/cm2) and (54.74 min. & 20 mA/cm2), respectively

Zhao et al. (2008) studied the optimization of adsorption conditions of powdered alum sludge (PAS) as low-cost adsorbent for the removal of three P-species (ortho-P, poly-P and organic-P) from wastewater using the three response surface quadratic models in terms of three factors with BBD to determine the effect of pH (from 4 to 7), PAS mass (from 0.1 to 0.5 g) and PAS particle size (from 125 to 420 μm) on the response levels (removal efficiencies of the three P-species). Parameters (pH, PAS mass and PAS particle size) had a significant effect on the removal of each of the P species. Finally, optimal conditions for P species removal were determined at which the P-removals of 99.8 per cent (for ortho-P), 94.9 per cent (for poly-P) and 94.8 per cent (for organic-P) were achieved, respectively. The results derived from the verification experiments in agreement thereupon expected by the models.

M. F. Alkhatib et.al (2014) conducted research on " Application of response surface methodology (RSM) for optimization of color removal from POME by granular activated carbon". Author studied color removal from palm oil effluent on granular activated carbon using Response Surface Methodology (RSM) Quadratic model was developed by author using batch experiment parameters for removal of color. This model predicted the experimental data to the accuracy with R2 of 0.9148. Influence of pH, dose of granular activated carbon and contact time was found on color removal. While removal decreased with increase in pH scale, it showed increase with contact time and GAC dose. Author applied Langmuir and Freundlich isotherm models to the equilibrium data. Author found that application of GAC, the adsorption process followed Langmuir isotherm can remove POME color.

VahapYonten et.al (2017) worked on " The Using of Rsm on Removal of Methylene Blue from Aqueous Solutions by Grape Seed (Tunceli-Elazıg) as a Low Cost and Ecofriendly Adsorbent". Removal of Methylene Blue (MB) from synthetic wastewater was done by transforming grape seeds into active. Optimization process of grape seeds which are waste products of the wine and juice processes was completed using RSM by author. Author identified, selected and optimized the four parameters which can affect the removal in selected process and maximum MB removal was achieved. Author calculated the effects of each parameter on removal by using Central Composite Design (CCD) software. Author conducted empirical and statistical studies to see the values for independent parameters that achieved the maximum response were; pH 3.7, contact time 55.5 minutes, absorbent dose **1**.4 g, and initial concentration of 160 mgL-1. Author used this parameters for MB removal from synthetic wastewater at an approximate yield of 99% with the help of active carbon (*Vitis vinifera* seed). Author found that model developed supported the conducted study by 82%.

Bong-yulTaket.al(2015) conducted research on " Optimization of color and COD removal from livestock wastewater by electro coagulation process: Application of Box–Behnken design (BBD)".Author identified major operating variables and optimized the condition using Box–Behnken design and response surface methodology. Experimental data and predicted value of responses obtained using response function agree well with each other. Author found that economical operative conditions and removal efficiencies were @ pH of 8, current density of30 mA/cm2, electrolysis time of 30 min and NaCl concentration of1 g/L, and 95.2% (Y1) and 93 (Y2), respectively.

V Sangeetha et.al (2014) conducted research on "Optimization of process parameters for COD removal by Coagulation Treatment using Box–Behnken design". Author performed laboratory study to find out sago wastewater treatment using coagulation and alum as coagulant. Response surface methodology (RSM) was used by author for optimizing coagulation treatment condition, Operational parameters namely dosage of alum (Al2 (SO 4) 3) (mg/l), pH and wastewater concentration (g/l) were varied between 50-150mg/l, 3–5 and 10-30g/l respectively. Author used Pareto analysis of variance (ANOVA) for analyzing result. Author found that Optimum condition at 100mg/l of alum dosage, 4.5 pH and 23.5 g/l concentration, COD removal efficiency was found to be 67.86%. Author concluded that coagulation treatment can be an alternative approach for treatment of sago waste water.

M. Mohsen Nourouzi et.al (2011) conducted research on "Optimization of reactive dye removal by sequential electro coagulation–flocculation method: comparing ANN and RSM prediction "Author investigated removal of reactive Black dye of an aqueous solution by using sequential electro coagulation–flocculation method. Impact of operational parameters i.e. current density, treatment time, solution conductivity and polymer dosage were investigated by author. He modeled the effect of independent variables on percentage of dye removal by using two models i.e. artificial neural network (ANN) and also the response surface methodology (RSM). Author based on the result found concluded that current density, treatment time and dosage of polymer had the most significant effect on percentage of dye removal (p o 0.001). In addition, interaction between time and current density, time and dose of polymer, current density and dose of polymer in addition significantly affected the proportion of dye removal (p ¼ 0.034, 0.003 and 0.024, respectively). It was shown that both the ANN and RSM models were able to predict well the experimental results (R2 4 0.8)

Ali Fakhri et.al (2014) conducted research on " Application of response surface methodology to optimize the process variables for fluoride ion removal using maghemite(c-Fe2O3) nanoparticles "RSM was used by Author to determine effects of the major independent variables (temperature, adsorbent dose and pH) and their interactions during fluoride ion adsorption. Response surface methodology (RSM) based on three-level three-factorial Box–Behnken design (BBD) was used by him. Author found that optimized value of temperature, maghemite nanoparticle dose and pH for fluoride sorption were 313 K, 0.5 g/L, and 4, respectively. Author fitted various adsorption isotherms such as Langmuir, Freundlich, Temkin and Florry–Huggins to investigate the mechanism of fluoride removal. The experimental information revealed that Langmuir isotherm ga ve additional satisfactory suitable fluoride removal.The adsorption process was rapid and obeyed pseudo-second-order kinetics. The values of thermodynamic parameters DG, DH and DS indicated that adsorption was spontaneous and endothermic in nature.

Mohammad Reza RezaeiKahkha et.al (2015) conducted research on " Optimization of Affctive Parameter on Cadmium Removal From an Aqueous Solution by Citrullus colocynthis Powdered Fruits by Response Surface".Author removal of cadmium from aqueous solutions using C. colocynthis fruit powder. The Box-Behnken design (BBD) was used to optimize the dosage of adsorbent and the effect of three parameters such as pH, initial concentration of cadmium. Author found that the optimum condition for percentage extraction of cadmium by C. colocynthis by using BBD design was @ pH = 4.5, initial cadmium concentration of 31.22 and adsorbent dosage of 3.75 g/L. Analysis of variance (ANOVA) and R2 = 0.98 showed that the model was ready to predict the removal of cadmium by C. colocynthis fruit powder. Based on the ANOVA results, the models report high R2 value of 99% for cadmium removal, which is very high and advocates a high correlation between the observed values and the predicted value.

III. CONCLUSION

By studying the results of application of statistical approach i.e. Response surface methodology for removal of pollutant from wastewater by citing several journals one can conclude that Response surface methodology predict the approximate result and not much difference is found when predicted results matched with experimental results conducted by different authors for different parameters.

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