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A Study of Adsorption Dynamics of Biologically Active Plants

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Abstract: *Alstonia scholaris* is a biologically active and important Devil tree. The medicinal importance pharmacology importance in particulars antiulcer activity of *Alstonia scholaris* in albino rats were Analyzed and reported. The juice of *Alstonia scholaris* to rats show a remarkable record with respect to ranitidine tablet (to cure ulcer). This result initiate the author to study chemo mimetic nature of plant material for the removal of heavy metal in synthetic solution also extended studies with modified *Alstonia scholaris* and *Wrightia Tinctoria*. An adsorption of 96% in all the cases was observed. A linear correlation with R^2 value of 0.977 was calculated from the linear plot of optical densities of *Alstonia Scholaris* and modified *Alstonia Scholaris* similar trend in adsorption was also noted. In the case of *Wrightia Tinctoria* instead of modified *Alstonia Scholaris*

I. INTRODUCTION

Literature survey has revealed the availability of several lowcost adsorbents materials, including straw-dust, cellulose, xanthate, straw, peat mass, wood, hard saw dust, *sagaum tectona grandis*, agricultural wastes, neem leaves, saw dust, barley straw, groundnut husk carbon, bicarbonate treated coconut husk, sediments, sand, iron, soil, alumina pillared clay (lv) oxide,. Aluminium oxide, fly ash, activated sludge, Portland cement clinker powder and discarded tire rubber.

The chemical nature of the surface of the adsorbent materials has relatively less significance. This factor is considered only secondary to the magnitude of the surface of the particles of adsorbent material. Reasons for the selection of an adsorbent material vary. However, frequently referred reason are the unusual surface properties of the adsorbent material and economics of its application. The adsorbent materials is so chosen that can be regenerated effectively. This make its application quite economical.

A. Freundlich Adsorption Isotherm

Solid surfaces can act as adsorbents for the removal of dissolved substances from a solution, for instance, activated carbon can be used as an adsorbent for the removal of acetic acid from its aqueous solution and also for the removal of ammonia from its aqueous solution. The phenomenon of adsorption of a solution is similar to that of gases and subjected to the same principles and factors applicable to adsorption of gases. Some adsorbents are specifically more effective in attracting certain substances to the extent of adsorption, while an increase in surface area operates directly to it.

Adsorption of solutes, like that of gases, involves the establishment of an equilibrium between the amount adsorbed on the surface and the concentration of the substances in solution. The variation of the extent of adsorption with concentration of the solute is usually represented

$$Y = K(C_{eq})^{1/n}$$

Y = mass of the substance adsorbed per unit Mass of the adsorbent. C_{eq} = concentration of the substance at equilibrium

K and n = empirical constants.

Taking log, we get,

$$\begin{aligned} \log y &= \log k + 1/n \log C_{eq} \\ &= 1/n \log C_{eq} + \log k \end{aligned}$$

The plot of log y versus log C_{eq} gives a straight line, the slope of it equals to $1/n$ and the intercept to k.

B. Weber – Morris Equation

Weber and Morris have suggested a relation between the amount of the adsorbate adsorbed and the contact-time. It has been stated that the amount of the adsorbable is almost directly proportional to the square root of contact-time, provided the adsorption process involves intraparticle diffusion as the rate determining step.

The weber –Morris equation is given as:

$$Q = \frac{X}{M} K_{id} T^{0.5}$$

Where,

Q = amount of the adsorbate adsorbed per unit weight of the adsorbent, mg g⁻¹.

X = amount of the adsorbate adsorbed, mg dm⁻³

T = contact time, s and

K_{id} = the rate constant for intraparticle diffusion, mg g⁻¹ min^{0.5}

C. Correlation Analysis

In any scientific study, experimentation is a common feature. The results of an experiment are recorded and these records are useful in deriving conclusions. To arrive at these conclusions, representation, interpretation and correlational analysis of the data are required. Correlation brings out the intensity of association existing between a pair of variables and it reveals the direction of movement of each pair. A positive association and a negative association indicate parallel movement and diametrically opposite movement respectively.

The term correlation analysis refers to the analysis of the total volume of results with empirical correlations in order to correlate one body of results with another so as to reveal the fundamental factors underlying reactivity.

System with the same linear free energy relationship is similar provided that there exists some simple and constant reaction mechanism. It is to be noted that to correlated equilibrium constants in a reaction series, the product must have similar structures throughout that series.

After finding out the direction of movement of a pair of variables, it is of interest to find cause and effect relations among them. The rate of change of a dependent variable is affected by a change in the cause variables. The relations are of different types. If the rate of change of a dependent variable is assumed constant throughout the course of the experiment the following linear relation is applied.

$$Y = b_0 + b_1 X$$

Where,

X = is the cause

Y is the effect

B, is the slope.

And b₀ is a constant.

But reality, a constant increase or decrease cannot be expected between two variables. A reaction, normally shows a slight jolt in the beginning and after stabilization, it may increase at an increasing rate, increase at a decreasing rate, decrease at an increasing rate, decreasing rate. To accommodate this phenomenon, the fit is expected to have a second derivative. This is possible only if the power of the independent variable is at least two. This suggests the use of quadratic equation and its general form is given below.

$$Y = b_0 + b_1 X + b_2 X^2$$

D. Wrightia Tinctoria

The leaves are acrid, thermogenic, anodyne and hypotensive and are very useful in adontagia, vitiated conditions of vata and hypertension. The seeds are bitter, astringent, acrid, carminative, constipating, depurative, anathematic and febrifuge. They are useful in vitiated conditions of Pitta and kapha, dyspepsia etc.

Its pungent fresh leaves quickly relieve toothaches. Leaves, quickly relieve toothaches. Leaves, flowers and fruits are source of a kind of indigo called pala-indigo. White, close grained wood looks like ivory and is much fever, diarrhea, roundworm and colic

E. Alstonia Scholaris

The Ayurveda herb, Alstonia scholaris leaves are arranged in group of seven as called by the name, saptaparana and its Latin name is Alstonia scholaris it is a large evergreen tree, found in Bengal, south India and an western coastal area. The physical appearance of upper surface of the leaves is green in colour and the lower surface is white either cutting the bark or leaves oozes white milky fluid this is used largely in Ayurveda medicine as a laxative and as an astringent for skin disorder, cutaneous and for upper purification process of Panjakarama.

II. EXPERIMENTAL METHODS

A. Doubly Distilled Water

Distill water and alkaline potassium permanganate were taken in an all glass Pyrex apparatus then distilled.

B. Glassware Cleaning

Glassware's were cleaned using soap soln. Then washed with tap water soaked with 10% HNO₃ over period of two days. These glassware's were cleaned again with tap water and rinsed with doubly distilled water.

C. Materials

Diphenyl Carbazide, K₂Cr₂O₇, ethanol, glacial acetic acid, conc H₂SO₄ of merck Quality were purchased purified. Medicinal plants of *Alstonia scholaris* modified *Alstonia Scholaris* and *Wrightia tinctoria* were collected and purified used for highest purity.

D. Apparatus Required

- 1) Colorimeter
- 2) pH meter
- 3) Digital balance
- 4) Hot air oven

III. PREPARATION OF STOCK SOLUTION

Synthetic solution of K₂Cr₂O₇ was prepared by weighing accurately 0.1g taken in a 1000ml of standard flask and made up to mark with distilled water.

- 1) *Diphenyl Carbazide Solution*: A solution of 1.5 – diphenyl carbazide (1.00g), glac. acetic acid (50mL) and ethylalcohol (450mL) was mixed well and taken in brown in color reagent bottles.
- 2) *Cow Dung*: Cow dung was collected. Cleaned with tap water about four times till to get the maximum dusts were removed, filter it. Then dried of shadow drying over a period of a month, powdered and kept the material in a brown bottle for use.
- 3) *Preparation of Adsorbent A: Alstonia scholaris* leaves were collected from a well grown tree. In these healthier leaves were separated out wash with tap water, distilled water and then partly dried. Then, cut into small pieces continue drying over a period of 168 hrs. The resulting powdered over a period of 19hrs. The resulting dried material is kept in desiccator and use.
- 4) *Modified Adsorbent B*: The modified adsorbent B was prepared by the equal (w/w) mixture of adsorbent A and dried cow dung.
- 5) *Preparation of Adsorbent C: Wrightia tinctoria* leaves were collected from a well grown tree. In these healthier leaves are separated out wash with tap water, distilled water and then partly dried cut into small pieces continuing drying over a period of 168 hrs powdered over a period of 19hrs. The resulting dried material is kept in desiccator and use.
- 6) *Estimation of Cr⁶⁺*: Hexavalent chromium reacts with 1,5 diphenyl carbazide in the acid medium produces a reddish – violet colored complex. The intensity of the complex observed in colorimeter. A series potassium dichromate solution containing 50,100,150 X 200 X 10⁻⁶dm³ of cr⁶⁺ soln. were prepared by diluting the stock solutions. One mL of diphenyl carbazide reagent was added to the solution. The color intensity was measured after 10mts of time interval at 540nm

IV. RESULTS AND DISCUSSION

The maximum absorption of synthetic solution and along with indicator are noted as 50x10⁻⁶ g/dm(table -1) keeping concentration of synthetic solution as same throughout the experiments (tables 2 to 17), change in volume and change in pH. The optical densities are measured with no change in time duration and adsorbent concentration.

The adsorptive power changes in certain cases with the change in physical observed. The result reflects remarkable adsorption of 96% at pH-3.0 using *Alstonia scholaris*, the same (96%) is noted in the case of modified *alstonia scholaris* and *wrightia tinctoria*.

The values are plotted against optical density using SPSS 10.00 software among the possible eleven forms of equation namely linear, logarithmic, inverse, quadratic, and cubic, posser compound, and logistic growth and exponential. The correlation study we have been utilizing linear functional relationship between two variables, which indirectly assume constant rate of the reaction with in the period of investigation which may increase (or) decrease. The mathematical form of the best fitted equation is

$$Y = b_0 + b_1x$$

Using this equation the concentration of adsorbate in the system are measured in tables (2) optical density of *alstonia scholaris* and optical density of modified *alstonia scholaris* shows a good linearity of $R= 0.977$ but after removing OD corresponding to 50ml (tables 17) also produces an excellent linearity.

Our main aim in this system is to observe the chemo mimetic nature of the medicinal plants.

Table – 1
Absorbance of Adsorbate Concentration

S.No	Concentration, 10^{-6}	Optical Density
1	10	3.57
2	20	4.0
3	30	4.54
4	40	5.0
5	50	6.2
6	60	8.5
7	70	11.0
8	80	14.2
9	90	20.0

MODEL: MOD_5.

Independent: VAR00001 Dependent Mth Rsq d.f. F Sigf b0 b1 VAR00002 LIN .977 7
291.49 .000 1.5464 .1535

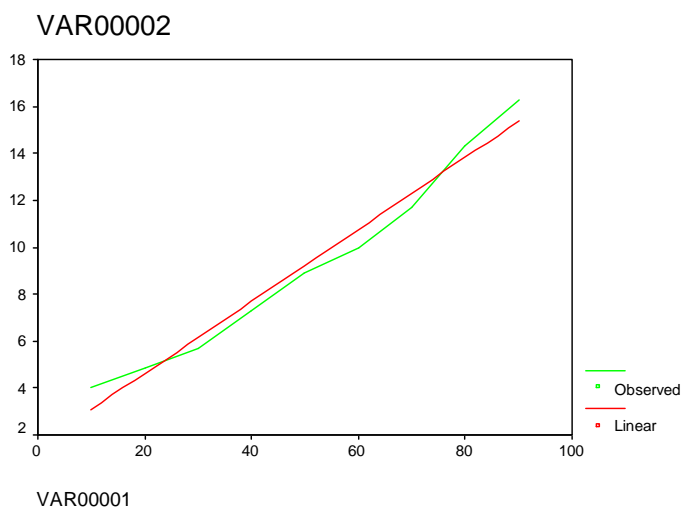


Fig. 1

Table – 2
Absorbance of Adsorbate at pH of 0.5
Adsorbent : A (500mg) Conc 0.5×10^{-6} g/lit Time : 2hrs

S.No	Volume, ml	Optical Density
1	50	7.14
2	100	6.66
3	150	5.88
4	200	5.26

MODEL: MOD_6.

Independent: VAR00004

Dependent Mth Rsq d.f. F Sigf b0 b1
VAR00005 LIN .993 2 266.26 .004 7.8400 -.0128

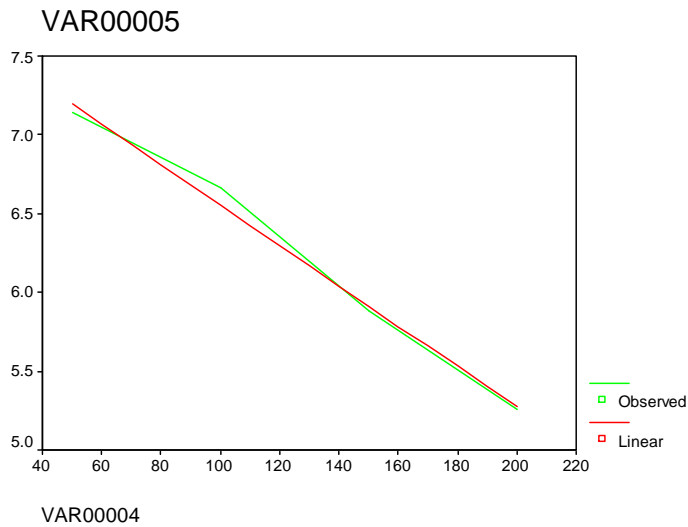


Fig. 2

Table – 3
Absorbance of Adsorbate at pH of 1.0
Adsorbent : A (500mg) Conc 1.0 X 10⁻⁶g/lit Time : 2hrs

S.No	Volume, ml	Optical Density
1	50	10.0
2	100	8.2
3	150	7.0
4	200	6.25

MODEL: MOD_7.

Independent: VAR00006

Dependent Mth Rsq d.f. F Sig b0 b1

VAR00007 LIN .966 2 56.01 .017 10.9750 -.0249

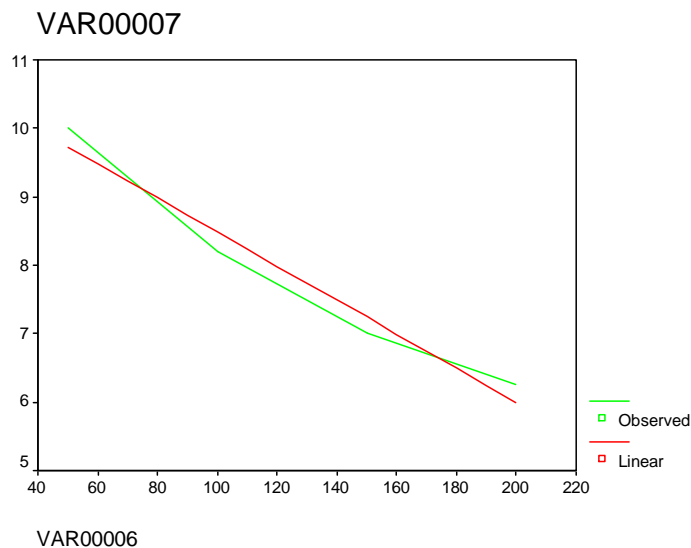


Fig 3

Table – 4
Absorbance of Adsorbate at pH of 2.0
Adsorbent : A (500mg)Conc. 2.0×10^{-6} g/lit Time: 2hrs

S.No	Volume, ml	Optical Density
1	50	4.54
2	100	2.94
3	150	2.0
4	200	1.61

MODEL: MOD_9.

Independent: VAR00010

Dependent Mth Rsq d.f. F Sigf b0 b1

VAR00011 LIN .930 2 26.41 .036 5.2100 -.0195

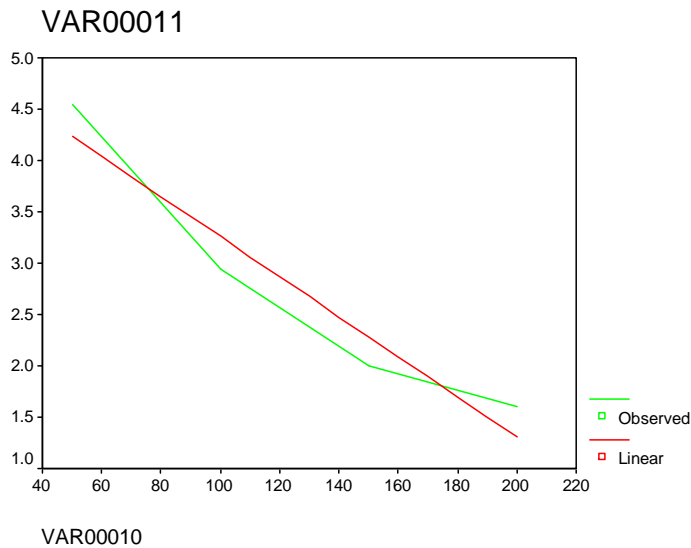


Fig – 4

Table – 5
Absorbance of Adsorbate at pH of 3.0
Adsorbent : A (500mg)Conc. 3.0×10^{-6} g/lit Time: 2hrs

S.No	Volume,ml	Optical Density
1	50	1.21
2	100	1.66
3	150	2.85
4	200	3.84

MODEL: MOD_12.

Independent: VAR00014

Dependent Mth Rsq d.f. F Sigf b0 b1

VAR00015 LIN .972 2 70.42 .014 .1200 .0182

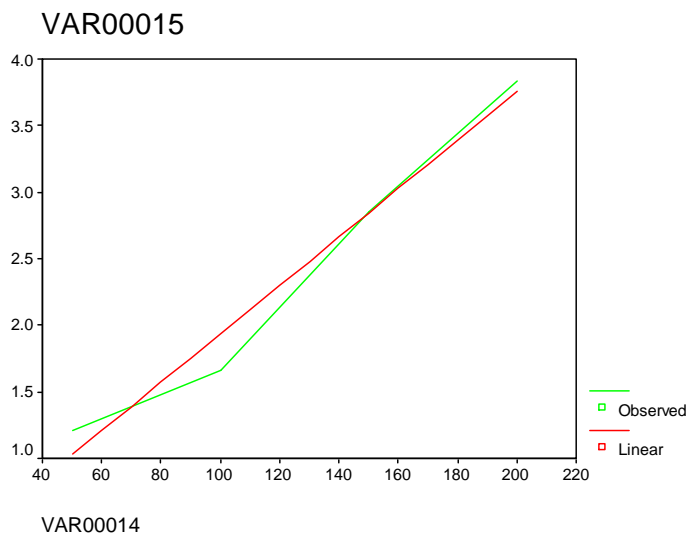


Fig – 5

Table – 6
pH Variation of Concentration of 50×10^{-6} g/lit
Adsorbent: A (500mg) Time: 2hrs

S.No	pH	Optical Density
1	1.0	10.0
2	1.5	50.0
3	2.0	4.54
4	2.5	1.03
5	3.0	1.11

MODEL: MOD_23.

Independent: VAR00028

Dependent Mth Rsq d.f. F Sigf b0 b1

VAR00029 LIN .257 3 1.04 .383 40.0360 -13.350

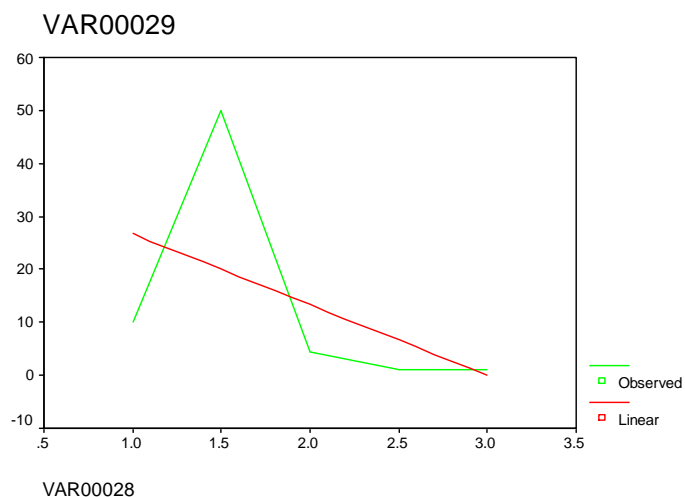


Fig. 6

Table – 7
pH Variation of Concentration of 100×10^{-6} g/lit
Adsorbent : A (500mg) Time : 2hrs

S.No	pH	Optical Density
1	1.0	7.69
2	1.5	14.28
3	2.0	2.9
4	2.5	1.8
5	3.0	1.6

MODEL: MOD_24.

Independent: VAR00028

Dependent Mth Rsq d.f. F Sigf b0 b1

VAR00029 LIN .257 3 1.04 .383 40.0360 -13.350

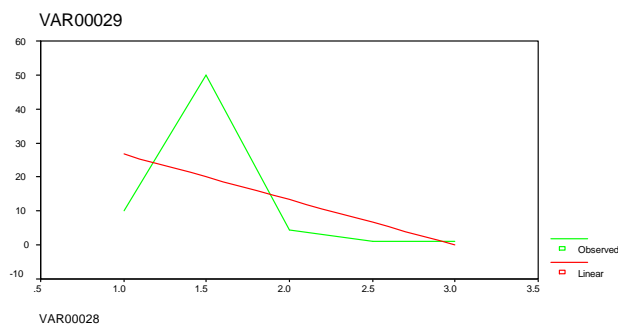


Fig. 7

Table – 8
pH Variation of Concentration of 200×10^{-6} g/lit
Adsorbent: A (500mg) Time : 2hrs

S.No	pH	Optical Density
1	1.0	6.25
2	1.5	5.88
3	2.0	1.61
4	2.5	1.09
5	3.0	3.84

Table – 9
Absorbance of Adsorbate of pH = 1.0
Adsorbent : B (500mg)
Conc 1.0×10^{-6} g/lit Time : 2hrs

S.No	Volume, ml	Optical Density
1	50	6.25
2	100	5.0
3	150	1.4
4	200	1.3

MODEL: MOD_14.

Independent: VAR00016

Dependent Mth Rsq d.f. F Sigf b0 b1

VAR00017 LIN .895 2 17.04 .054 8.0600 -.0362

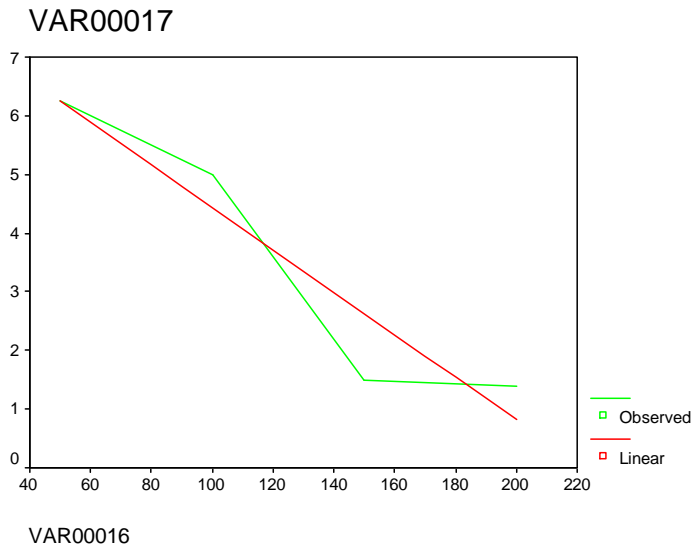


Fig. 9

Table – 10
Absorbance of Adsorbate of pH = 2.0
Adsorbent : B (500mg)
Conc 2.0×10^{-6} g/lit Time : 2hrs

S.No	Volume, ml	Optical Density
1	50	1.61
2	100	2.61
3	150	6.66
4	200	50.0

MODEL: MOD_16.

Independent: VAR00020

Dependent Mth Rsq d.f. F Sig b0 b1

VAR00021 LIN .651 2 3.73 .193 .4150 .0283

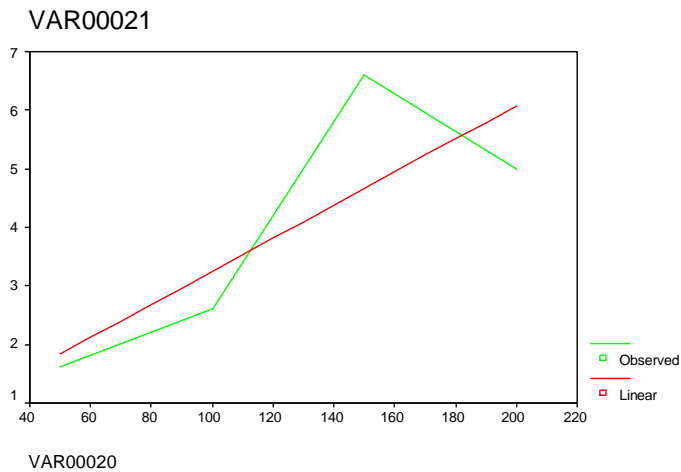


Fig 10

Table – 11
Absorbance of Adsorbate of pH = 3.0
Adsorbent : B (500mg)Conc 3.0 X 10⁻⁶g/lit Time: 2hrs

S.No	Volume, ml	Optical Density
1	50	0.48
2	100	0.64
3	150	0.91
4	200	2.43

MODEL: MOD_18.

Independent: VAR00024

Dependent Mth Rsq d.f. F Sigf b0 b1

VAR00025 LIN .780 2 7.10 .117 -.4150 .0122

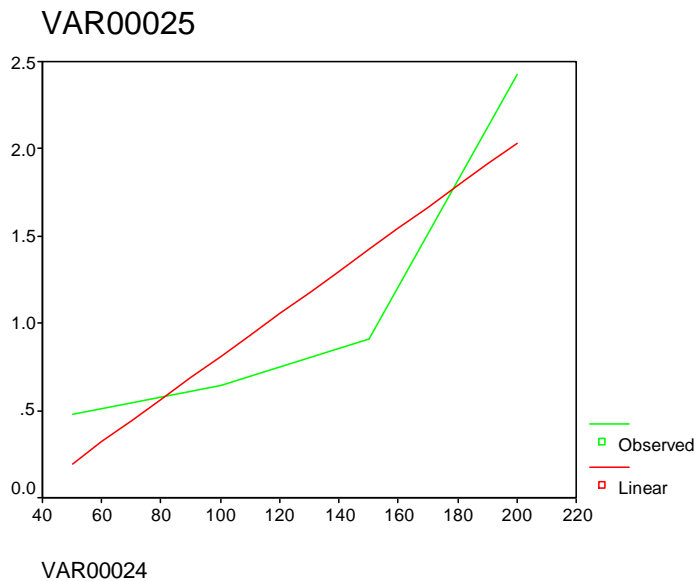


Fig. 11

Table – 12
Absorbance of Adsorbate of pH = 3.0
Adsorbent : C (500mg)Conc 1.0 X 10⁻⁶g/lit Time : 2hrs

S.No	Volume, ml	Optical Density
1	50	25.0
2	100	2.22
3	150	1.67
4	200	1.11

MODEL: MOD_20.

Independent: VAR00026

Dependent Mth Rsq d.f. F Sigf b0 b1

VAR00027 LIN .981 2 104.91 .009 3.0550 -.0096

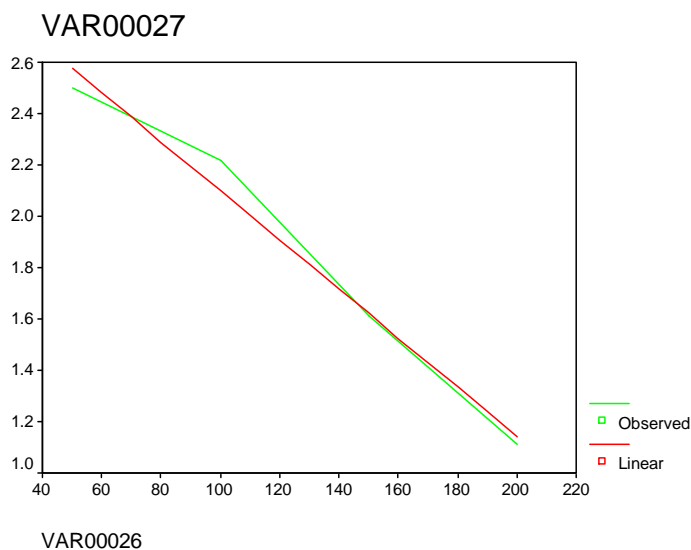


Fig. 12

Table – 13
pH Variation of Concentration of 50×10^{-6} g. lit
Adsorbent: B (500mg) Time: 2hrs

S.No	pH	Optical Density
1	1	6.25
2	1.5	0.93
3	2.0	1.61
4	2.5	0.51
5	3.0	0.48

Table – 14
pH Variation of Concentration 100×10^{-6} g. lit
Adsorbent : B (500mg) Time : 2hrs

S.No	pH	Optical Density
1	1	0.05
2	1.5	1.04
3	2.0	2.61
4	2.5	0.72
5	3.0	0.64

Table – 15
pH Variation of Concentration 200×10^{-6} g. lit
Adsorbent : B (500mg) Time : 2hrs

S.No	pH	Optical Density
1	1	1.38
2	1.5	3.47
3	2.0	5.0
4	2.5	3.3
5	3.0	2.4

Table – 16
Correlation table
Absorbent : A &B

S.No	pH	Optical Density
1	1.24	0.48
2	1.66	0.64
3	2.85	0.91
4	3.84	2.43

MODEL: MOD_28.

Independent: VAR00035

Dependent Mth Rsq d.f. F Sigf b0 b1

VAR00036 LIN .831 2 9.86 .088 -.5247 .6861

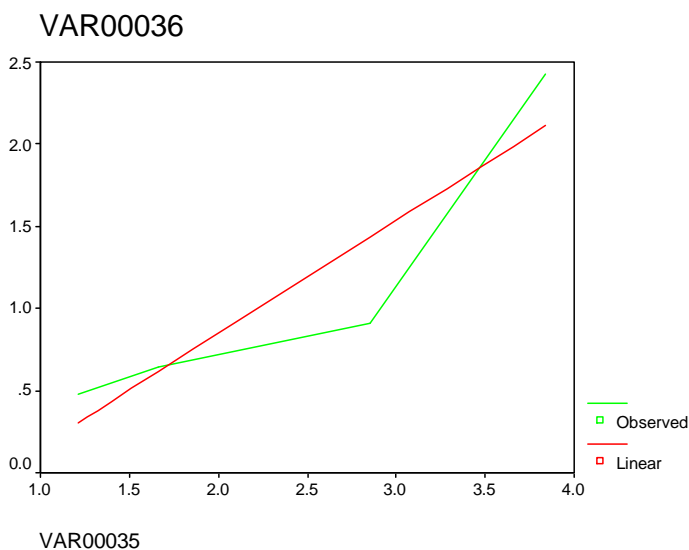


Fig. 16

Table – 17
Correlation Table
Absorbent : A &C

S.No	Optical Density	Optical Density
1	1.24	25.0
2	1.66	2.22
3	2.85	1.61
4	3.84	1.11

MODEL: MOD_29.

Independent: VAR00037

Dependent Mth Rsq d.f. F Sigf b0 b1

VAR00038 LIN 1.000 1 55778.7 .003 3.0642 -.5093

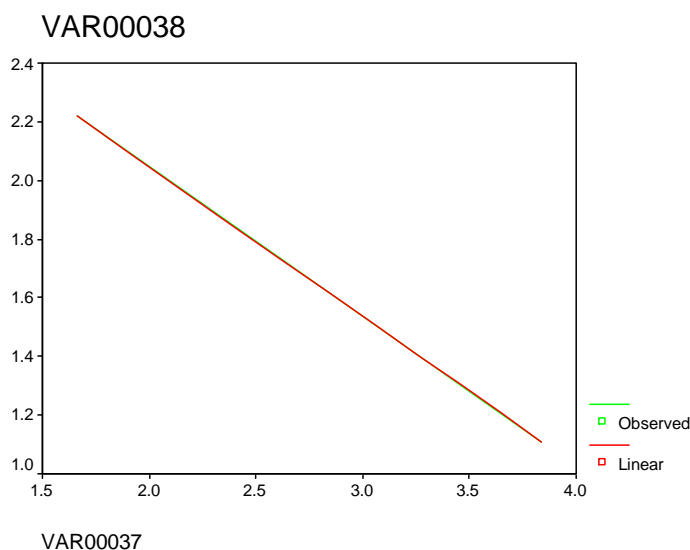


Fig. 17

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