Michaelis-Menten

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Question:

The below data represents the substrate concentration (S) and the observed velocity (v) based on an enzymology experiment.

1)Fit a non linear regression model that relates velocity to concentration using Michaelis-Menten equation .

2)Analyse and examine whether you can fit a simple linear regression model that relates velocity and substrate concentration by using any suitable transformation.

Variable of Interest:

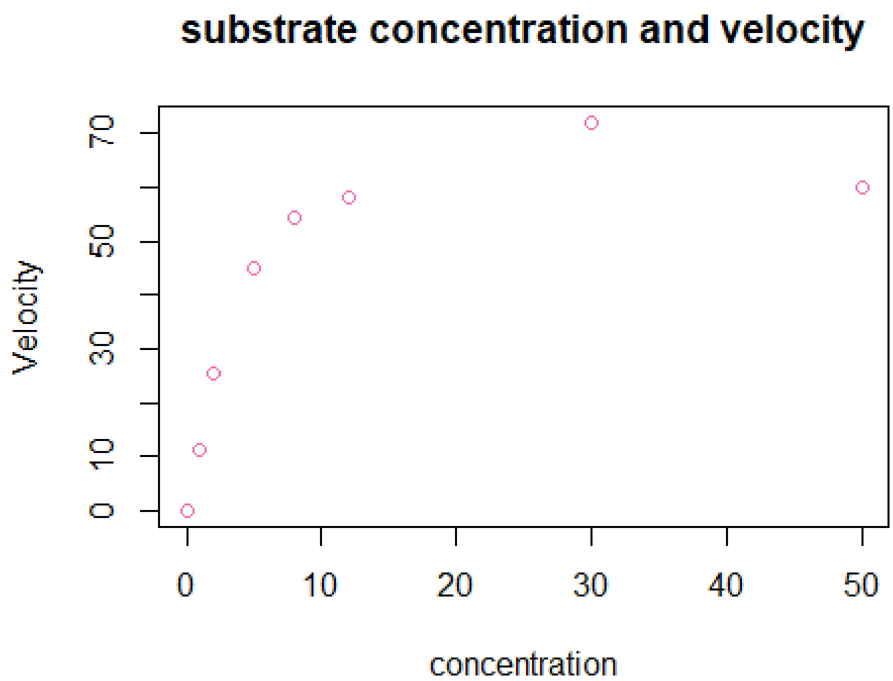
S : Concentration of the chemical substance

V: Velocity of the chemical substance.

Import dataset

```
library(readxl)
rate <- read_excel("C:/Users/mayur/Desktop/Mstat/Semesters/Tri-sem2/Regression/Dataset/rate.xlsx")
View(rate)
attach(rate)

plot(rate$S,rate$V,col="hotpink",xlab="concentration",ylab="Velocity",main="substrate concentration and velocity")
```




```
model1=nls(V~Vmax*S/(k_m+S),start=c(Vmax=72,k_m=5),data=rate)
model1

## Nonlinear regression model
##   model: V ~ Vmax * S/(k_m + S)
##    data: rate
##   Vmax    k_m
## 73.261  3.437
##  residual sum-of-squares: 156.4
##
## Number of iterations to convergence: 6
## Achieved convergence tolerance: 6.202e-06

summary(model1)

##
## Formula: V ~ Vmax * S/(k_m + S)
##
```

```
## Parameters:
##      Estimate Std. Error t value Pr(>|t|)
## Vmax  73.2614     4.5825  15.987  3.8e-06 ***
## k_m    3.4372     0.8173   4.205  0.00565 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.106 on 6 degrees of freedom
##
## Number of iterations to convergence: 6
## Achieved convergence tolerance: 6.202e-06
```

the value for k and v_max values are not zero and hence a significant value. r^2 not a good metric to study the fit since x and y are not linear . thus the value of v_max is 73.26 and k_m is 3.43

```
confint(model1)
```

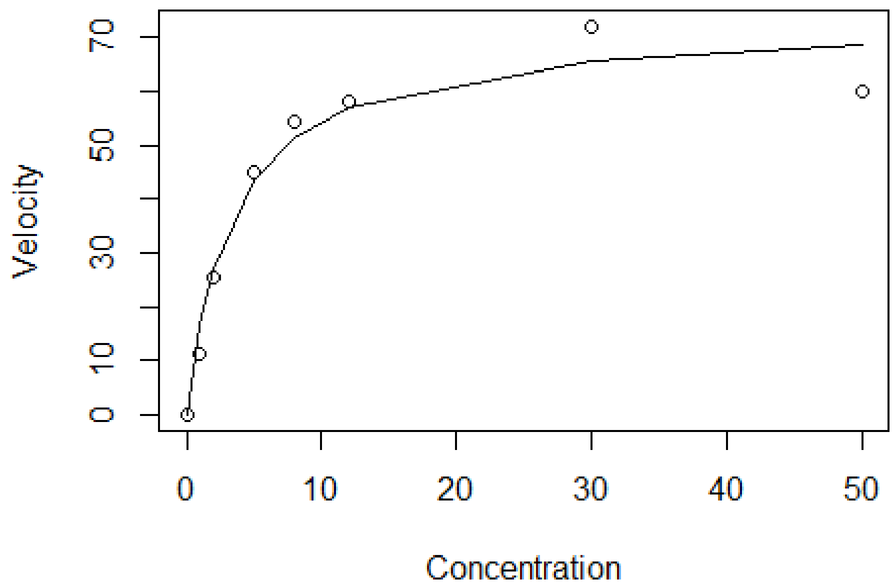
```
## Waiting for profiling to be done...
```

```
##          2.5%     97.5%
## Vmax 63.302914 84.889668
## k_m   1.958589  5.794501
```

95% of the time the true value will lie within this range

Vmax 63.302914 84.889668 k_m 1.958589 5.794501

```
plot(S,V,xlab="Concentration", ylab="Velocity")
lines(S,predict(model1))
```




```
summary(model1)

##
## Formula: V ~ Vmax * S/(k_m + S)
##
## Parameters:
##      Estimate Std. Error t value Pr(>|t|)
## Vmax  73.2614     4.5825  15.987  3.8e-06 ***
## k_m    3.4372     0.8173   4.205  0.00565 **
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##
## Residual standard error: 5.106 on 6 degrees of freedom
##
## Number of iterations to convergence: 6
## Achieved convergence tolerance: 6.202e-06

plot(resid(model1))
```
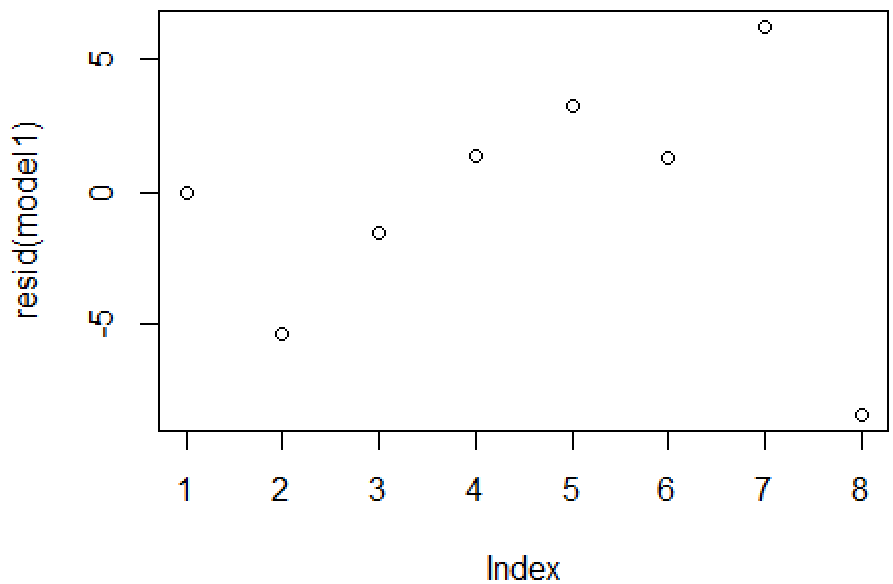
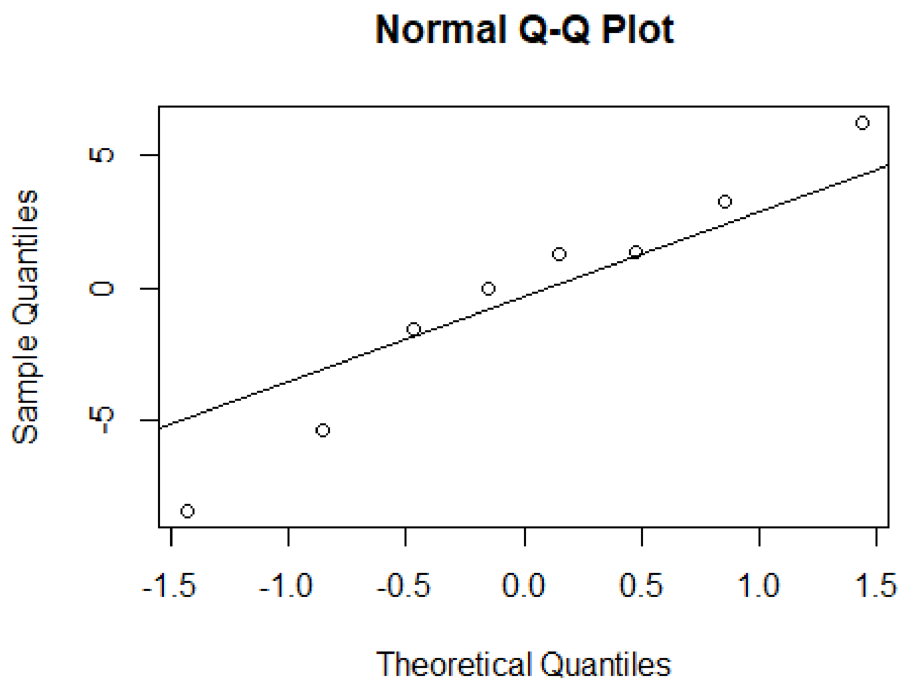




```
resid(model1)

## [1]  0.000000 -5.410856 -1.548379  1.384119  3.255559  1.250639  6.269496
## [8] -8.449099
## attr(,"label")
## [1] "Residuals"
```

normality

```
shapiro.test((resid(model1)))

## 
##  Shapiro-Wilk normality test
## 
## data:  (resid(model1))
## W = 0.96435, p-value = 0.8504

qqnorm(resid(model1))
qqline(resid(model1))
```



since the p value is greater than alpha(0.05) thus it follows normality condition. We can also infer the same from the above plot.

Transformation to linear model.

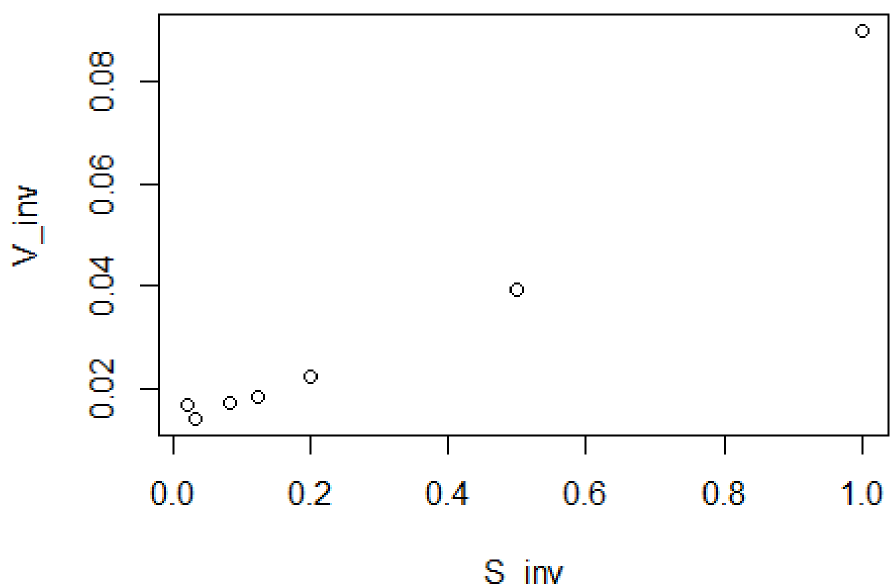
To perform linear regression, we need to have a function of V be linearly related to a function of [S]. This is achieved via taking the reciprocal of both sides of this equation.

$$\frac{1}{V} = \frac{[S] + K_m}{V_{\max}[S]} = \frac{1}{V_{\max}} + \frac{K_m}{V_{\max}} \frac{1}{[S]}$$

Thus, we have a linear relationship between 1/ V ,the response variable, and 1/S ,the explanatory variable

```
library(readxl)
rate1 <- read_excel("C:/Users/mayur/Desktop/Mstat/Semesters/Tri-sem2/Regression/Dataset/rate1.xlsx")
```

```
View(rate1)
attach(rate1)

S_inv=1/(s)
V_inv=1/(v)
plot(S_inv,V_inv)
```




```
model2=lm(V_inv~S_inv)
model2

##
## Call:
## lm(formula = V_inv ~ S_inv)
##
## Coefficients:
## (Intercept)        S_inv
##     0.00996      0.07551

summary(model2)
```

```
##
## Call:
## lm(formula = V_inv ~ S_inv)
##
## Residuals:
##          1          2          3          4          5          6          7
##  0.0046231 -0.0083435 -0.0027401 -0.0010499  0.0009298  0.0014119  0.0051687
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.009960   0.002519   3.954   0.0108 *
## S_inv       0.075507   0.005814  12.988 4.82e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.005083 on 5 degrees of freedom
## Multiple R-squared:  0.9712, Adjusted R-squared:  0.9655
## F-statistic: 168.7 on 1 and 5 DF,  p-value: 4.824e-05
```

Normality and Constant Variance Assumption

```
shapiro.test(resid(model2))
```

```
##
##  Shapiro-Wilk normality test
##
## data:  resid(model2)
## W = 0.93643, p-value = 0.6068
```

```
library(lmtest)
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
bptest(model2)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  model2
## BP = 1.2317, df = 1, p-value = 0.2671
```

since for both p values are greater than alpha, we accept null hypothesis and say that it follows normal distribution and has constant variance

Conclusion: Thus, we have demonstrated Michaelis-Menten model for the given data-set and have demonstrated that an inverse transformation to the model can make it a linear model.