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Class: BE-9
Batch No: R9

Assignment 12 Output

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```
> library("tidyverse")
> wine.data <- read.csv("winequalityN.csv")
> head(wine.data)
   type fixed.acidity volatile.acidity citric.acid residual.sugar chlorides
1 white           7.0             0.27        0.36           20.7     0.045
2 white           6.3             0.30        0.34            1.6     0.049
3 white           8.1             0.28        0.40            6.9     0.050
4 white           7.2             0.23        0.32            8.5     0.058
5 white           7.2             0.23        0.32            8.5     0.058
6 white           8.1             0.28        0.40            6.9     0.050
  free.sulfur.dioxide total.sulfur.dioxide density   pH sulphates alcohol
1                  45                  170  1.0010 3.00      0.45     8.8
2                  14                  132  0.9940 3.30      0.49     9.5
3                  30                   97  0.9951 3.26      0.44    10.1
4                  47                  186  0.9956 3.19      0.40     9.9
5                  47                  186  0.9956 3.19      0.40     9.9
6                  30                   97  0.9951 3.26      0.44    10.1
  quality
1       6
2       6
3       6
4       6
5       6
6       6
> dim(wine.data)
[1] 6497   13
> colnames(wine.data)
 [1] "type"                "fixed.acidity"       "volatile.acidity"
 [4] "citric.acid"         "residual.sugar"      "chlorides"
 [7] "free.sulfur.dioxide" "total.sulfur.dioxide" "density"
[10] "pH"                  "sulphates"           "alcohol"
[13] "quality"
> summary(wine.data)
     type           fixed.acidity    volatile.acidity  citric.acid
 Length:6497        Min.   : 3.800   Min.   :0.0800   Min.   :0.0000
 Class :character   1st Qu.: 6.400   1st Qu.:0.2300   1st Qu.:0.2500
```

```
Mode  :character   Median : 7.000   Median :0.2900   Median :0.3100
                   Mean   : 7.217   Mean   :0.3397   Mean   :0.3187
                   3rd Qu.: 7.700   3rd Qu.:0.4000   3rd Qu.:0.3900
                   Max.   :15.900   Max.   :1.5800   Max.   :1.6600
                   NA's   :10       NA's   :8        NA's   :3
residual.sugar     chlorides       free.sulfur.dioxide total.sulfur.dioxide
Min.   : 0.600   Min.   :0.00900   Min.   :  1.00      Min.   :  6.0
1st Qu.: 1.800   1st Qu.:0.03800   1st Qu.: 17.00      1st Qu.: 77.0
Median : 3.000   Median :0.04700   Median : 29.00      Median :118.0
Mean   : 5.444   Mean   :0.05604   Mean   : 30.53      Mean   :115.7
3rd Qu.: 8.100   3rd Qu.:0.06500   3rd Qu.: 41.00      3rd Qu.:156.0
Max.   :65.800   Max.   :0.61100   Max.   :289.00      Max.   :440.0
NA's   :2        NA's   :2
   density            pH          sulphates         alcohol
Min.   :0.9871   Min.   :2.720   Min.   :0.2200   Min.   : 8.00
1st Qu.:0.9923   1st Qu.:3.110   1st Qu.:0.4300   1st Qu.: 9.50
Median :0.9949   Median :3.210   Median :0.5100   Median :10.30
Mean   :0.9947   Mean   :3.218   Mean   :0.5312   Mean   :10.49
3rd Qu.:0.9970   3rd Qu.:3.320   3rd Qu.:0.6000   3rd Qu.:11.30
Max.   :1.0390   Max.   :4.010   Max.   :2.0000   Max.   :14.90
                 NA's   :9       NA's   :4
   quality
Min.   :3.000
1st Qu.:5.000
Median :6.000
Mean   :5.818
3rd Qu.:6.000
Max.   :9.000

> glimpse(wine.data)
Rows: 6,497
Columns: 13
$ type                <chr> "white", "white", "white", "white", "white", "...
$ fixed.acidity        <dbl> 7.0, 6.3, 8.1, 7.2, 7.2, 8.1, 6.2, 7.0, 6.3, 8...
$ volatile.acidity     <dbl> 0.27, 0.30, 0.28, 0.23, 0.23, 0.28, 0.32, 0.27...
$ citric.acid          <dbl> 0.36, 0.34, 0.40, 0.32, 0.32, 0.40, 0.16, 0.36...
$ residual.sugar       <dbl> 20.70, 1.60, 6.90, 8.50, 8.50, 6.90, 7.00, 20....
$ chlorides            <dbl> 0.045, 0.049, 0.050, 0.058, 0.058, 0.050, 0.04...
$ free.sulfur.dioxide  <dbl> 45, 14, 30, 47, 47, 30, 30, 45, 14, 28, 11, 17...
$ total.sulfur.dioxide <dbl> 170, 132, 97, 186, 186, 97, 136, 170, 132, 129...
$ density              <dbl> 1.0010, 0.9940, 0.9951, 0.9956, 0.9956, 0.9951...
$ pH                   <dbl> 3.00, 3.30, 3.26, 3.19, 3.19, 3.26, 3.18, 3.00...
$ sulphates            <dbl> 0.45, 0.49, 0.44, 0.40, 0.40, 0.44, 0.47, 0.45...
$ alcohol              <dbl> 8.8, 9.5, 10.1, 9.9, 9.9, 10.1, 9.6, 8.8, 9.5,...
```

```
$ quality             <int> 6, 6, 6, 6, 6, 6, 6, 6, 6, 6, 5, 5, 5, 7, 5, 7...
> #converting "type" column to numeric type required for PCA
> wine.data$type <- ifelse(wine.data$type == "white",1,0)
> table(wine.data$type)

   0    1
1599 4898
> #checking null values
> sum_na <- sum(is.na(wine.data))
> print(paste("NA Data: ", sum_na))
[1] "NA Data:  38"
> #removing data with null values in columns (38 records)
> wine.data <- wine.data[complete.cases(wine.data),]
> #attach dataset to directly refer columns by name instead of using $
> attach(wine.data)
> #store wine quality in variable target
> target <- wine.data[,ncol(wine.data)]
> length(target)
[1] 6463
> #choose all other columns of the dataframe for PCA
> X <-
cbind(type,fixed.acidity,volatile.acidity,citric.acid,residual.sugar,chlorides,free.sulfur.dioxide,total.
sulfur.dioxide,density,pH,sulphates,alcohol)
> class(X)
[1] "matrix" "array"
> #find Correlation-Matrix
> X
      type fixed.acidity volatile.acidity citric.acid residual.sugar
 [1,]    1          7.00             0.270        0.36         20.70
 [2,]    1          6.30             0.300        0.34          1.60
 [3,]    1          8.10             0.280        0.40          6.90
 [4,]    1          7.20             0.230        0.32          8.50
 [5,]    1          7.20             0.230        0.32          8.50
 [6,]    1          8.10             0.280        0.40          6.90
 [7,]    1          6.20             0.320        0.16          7.00
 [8,]    1          7.00             0.270        0.36         20.70
 [9,]    1          6.30             0.300        0.34          1.60
[10,]    1          8.10             0.220        0.43          1.50
[11,]    1          8.10             0.270        0.41          1.45
[12,]    1          8.60             0.230        0.40          4.20
[13,]    1          7.90             0.180        0.37          1.20
[14,]    1          6.60             0.160        0.40          1.50
[15,]    1          8.30             0.420        0.62         19.25
[16,]    1          6.60             0.170        0.38          1.50
```

| | | | | | |
|---|---|---|---|---|---|
| [17,] | 1 | 6.30 | 0.480 | 0.04 | 1.10 |
| [18,] | 1 | 7.40 | 0.340 | 0.42 | 1.10 |
| [19,] | 1 | 6.50 | 0.310 | 0.14 | 7.50 |
| [20,] | 1 | 6.20 | 0.660 | 0.48 | 1.20 |
| [21,] | 1 | 6.40 | 0.310 | 0.38 | 2.90 |
| [22,] | 1 | 6.80 | 0.260 | 0.42 | 1.70 |
| [23,] | 1 | 7.60 | 0.670 | 0.14 | 1.50 |
| [24,] | 1 | 6.60 | 0.270 | 0.41 | 1.30 |
| [25,] | 1 | 7.00 | 0.250 | 0.32 | 9.00 |
| [26,] | 1 | 6.90 | 0.240 | 0.35 | 1.00 |
| [27,] | 1 | 7.00 | 0.280 | 0.39 | 8.70 |
| [28,] | 1 | 7.40 | 0.270 | 0.48 | 1.10 |
| [29,] | 1 | 7.20 | 0.320 | 0.36 | 2.00 |
| [30,] | 1 | 8.50 | 0.240 | 0.39 | 10.40 |
| [31,] | 1 | 8.30 | 0.140 | 0.34 | 1.10 |
| [32,] | 1 | 7.40 | 0.250 | 0.36 | 2.05 |
| [33,] | 1 | 5.80 | 0.270 | 0.20 | 14.95 |
| [34,] | 1 | 7.30 | 0.280 | 0.43 | 1.70 |
| [35,] | 1 | 6.50 | 0.390 | 0.23 | 5.40 |
| [36,] | 1 | 7.00 | 0.330 | 0.32 | 1.20 |
| [37,] | 1 | 7.30 | 0.240 | 0.39 | 17.95 |
| [38,] | 1 | 7.30 | 0.240 | 0.39 | 17.95 |
| [39,] | 1 | 6.70 | 0.230 | 0.39 | 2.50 |
| [40,] | 1 | 6.70 | 0.240 | 0.39 | 2.90 |
| [41,] | 1 | 7.00 | 0.310 | 0.26 | 7.40 |
| [42,] | 1 | 6.60 | 0.240 | 0.27 | 1.40 |
| [43,] | 1 | 6.70 | 0.230 | 0.26 | 1.40 |
| [44,] | 1 | 7.40 | 0.180 | 0.31 | 1.40 |
| [45,] | 1 | 6.20 | 0.450 | 0.26 | 4.40 |
| [46,] | 1 | 6.20 | 0.460 | 0.25 | 4.40 |
| [47,] | 1 | 7.00 | 0.310 | 0.26 | 7.40 |
| [48,] | 1 | 6.90 | 0.190 | 0.35 | 5.00 |
| [49,] | 1 | 7.20 | 0.190 | 0.31 | 1.60 |
| [50,] | 1 | 6.60 | 0.250 | 0.29 | 1.10 |
| [51,] | 1 | 6.20 | 0.160 | 0.33 | 1.10 |
| [52,] | 1 | 6.40 | 0.180 | 0.35 | 1.00 |
| [53,] | 1 | 6.90 | 0.250 | 0.35 | 1.30 |
| [54,] | 1 | 7.20 | 0.210 | 0.34 | 11.90 |
| [55,] | 1 | 6.00 | 0.190 | 0.26 | 12.40 |
| [56,] | 1 | 6.60 | 0.380 | 0.15 | 4.60 |
| [57,] | 1 | 7.40 | 0.200 | 0.36 | 1.20 |
| [58,] | 1 | 6.80 | 0.220 | 0.24 | 4.90 |
| [59,] | 1 | 6.00 | 0.190 | 0.26 | 12.40 |
| [60,] | 1 | 7.00 | 0.470 | 0.07 | 1.10 |

| | | | | | |
|---|---|---|---|---|---|
| [61,] | 1 | 6.60 | 0.380 | 0.15 | 4.60 |
| [62,] | 1 | 7.20 | 0.240 | 0.27 | 1.40 |
| [63,] | 1 | 6.20 | 0.350 | 0.03 | 1.20 |
| [64,] | 1 | 6.40 | 0.260 | 0.24 | 6.40 |
| [65,] | 1 | 6.70 | 0.250 | 0.13 | 1.20 |
| [66,] | 1 | 6.70 | 0.230 | 0.31 | 2.10 |
| [67,] | 1 | 7.40 | 0.240 | 0.29 | 10.10 |
| [68,] | 1 | 6.20 | 0.270 | 0.43 | 7.80 |
| [69,] | 1 | 6.80 | 0.300 | 0.23 | 4.60 |
| [70,] | 1 | 6.00 | 0.270 | 0.28 | 4.80 |
| [71,] | 1 | 8.60 | 0.230 | 0.46 | 1.00 |
| [72,] | 1 | 6.70 | 0.230 | 0.31 | 2.10 |
| [73,] | 1 | 7.40 | 0.240 | 0.29 | 10.10 |
| [74,] | 1 | 7.10 | 0.180 | 0.36 | 1.40 |
| [75,] | 1 | 7.00 | 0.320 | 0.34 | 1.30 |
| [76,] | 1 | 7.40 | 0.180 | 0.30 | 8.80 |
| [77,] | 1 | 6.70 | 0.540 | 0.28 | 5.40 |
| [78,] | 1 | 6.80 | 0.220 | 0.31 | 1.40 |
| [79,] | 1 | 7.10 | 0.200 | 0.34 | 16.00 |
| [80,] | 1 | 7.10 | 0.340 | 0.20 | 6.10 |
| [81,] | 1 | 7.30 | 0.220 | 0.30 | 8.20 |
| [82,] | 1 | 7.10 | 0.430 | 0.61 | 11.80 |
| [83,] | 1 | 7.10 | 0.440 | 0.62 | 11.80 |

| | chlorides | free.sulfur.dioxide | total.sulfur.dioxide | density | pH |
|---|---|---|---|---|---|
| [1,] | 0.045 | 45.0 | 170.0 | 1.001000 | 3.00 |
| [2,] | 0.049 | 14.0 | 132.0 | 0.994000 | 3.30 |
| [3,] | 0.050 | 30.0 | 97.0 | 0.995100 | 3.26 |
| [4,] | 0.058 | 47.0 | 186.0 | 0.995600 | 3.19 |
| [5,] | 0.058 | 47.0 | 186.0 | 0.995600 | 3.19 |
| [6,] | 0.050 | 30.0 | 97.0 | 0.995100 | 3.26 |
| [7,] | 0.045 | 30.0 | 136.0 | 0.994900 | 3.18 |
| [8,] | 0.045 | 45.0 | 170.0 | 1.001000 | 3.00 |
| [9,] | 0.049 | 14.0 | 132.0 | 0.994000 | 3.30 |
| [10,] | 0.044 | 28.0 | 129.0 | 0.993800 | 3.22 |
| [11,] | 0.033 | 11.0 | 63.0 | 0.990800 | 2.99 |
| [12,] | 0.035 | 17.0 | 109.0 | 0.994700 | 3.14 |
| [13,] | 0.040 | 16.0 | 75.0 | 0.992000 | 3.18 |
| [14,] | 0.044 | 48.0 | 143.0 | 0.991200 | 3.54 |
| [15,] | 0.040 | 41.0 | 172.0 | 1.000200 | 2.98 |
| [16,] | 0.032 | 28.0 | 112.0 | 0.991400 | 3.25 |
| [17,] | 0.046 | 30.0 | 99.0 | 0.992800 | 3.24 |
| [18,] | 0.033 | 17.0 | 171.0 | 0.991700 | 3.12 |
| [19,] | 0.044 | 34.0 | 133.0 | 0.995500 | 3.22 |
| [20,] | 0.029 | 29.0 | 75.0 | 0.989200 | 3.33 |

| | | | |
|---|---|---|---|
| [21,] | 0.038 | 19.0 | 102.0 0.991200 3.17 |
| [22,] | 0.049 | 41.0 | 122.0 0.993000 3.47 |
| [23,] | 0.074 | 25.0 | 168.0 0.993700 3.05 |
| [24,] | 0.052 | 16.0 | 142.0 0.995100 3.42 |
| [25,] | 0.046 | 56.0 | 245.0 0.995500 3.25 |
| [26,] | 0.052 | 35.0 | 146.0 0.993000 3.45 |
| [27,] | 0.051 | 32.0 | 141.0 0.996100 3.38 |
| [28,] | 0.047 | 17.0 | 132.0 0.991400 3.19 |
| [29,] | 0.033 | 37.0 | 114.0 0.990600 3.10 |
| [30,] | 0.044 | 20.0 | 142.0 0.997400 3.20 |
| [31,] | 0.042 | 7.0 | 47.0 0.993400 3.47 |
| [32,] | 0.050 | 31.0 | 100.0 0.992000 3.19 |
| [33,] | 0.044 | 22.0 | 179.0 0.996200 3.37 |
| [34,] | 0.080 | 21.0 | 123.0 0.990500 3.19 |
| [35,] | 0.051 | 25.0 | 149.0 0.993400 3.24 |
| [36,] | 0.053 | 38.0 | 138.0 0.990600 3.13 |
| [37,] | 0.057 | 45.0 | 149.0 0.999900 3.21 |
| [38,] | 0.057 | 45.0 | 149.0 0.999900 3.21 |
| [39,] | 0.172 | 63.0 | 158.0 0.993700 3.11 |
| [40,] | 0.173 | 63.0 | 157.0 0.993700 3.10 |
| [41,] | 0.069 | 28.0 | 160.0 0.995400 3.13 |
| [42,] | 0.057 | 33.0 | 152.0 0.993400 3.22 |
| [43,] | 0.060 | 33.0 | 154.0 0.993400 3.24 |
| [44,] | 0.058 | 38.0 | 167.0 0.993100 3.16 |
| [45,] | 0.063 | 63.0 | 206.0 0.994000 3.27 |
| [46,] | 0.066 | 62.0 | 207.0 0.993900 3.25 |
| [47,] | 0.069 | 28.0 | 160.0 0.995400 3.13 |
| [48,] | 0.067 | 32.0 | 150.0 0.995000 3.36 |
| [49,] | 0.062 | 31.0 | 173.0 0.991700 3.35 |
| [50,] | 0.068 | 39.0 | 124.0 0.991400 3.34 |
| [51,] | 0.057 | 21.0 | 82.0 0.991000 3.32 |
| [52,] | 0.045 | 39.0 | 108.0 0.991100 3.31 |
| [53,] | 0.039 | 29.0 | 191.0 0.990800 3.13 |
| [54,] | 0.043 | 37.0 | 213.0 0.996200 3.09 |
| [55,] | 0.048 | 50.0 | 147.0 0.997200 3.30 |
| [56,] | 0.044 | 25.0 | 78.0 0.993100 3.11 |
| [57,] | 0.038 | 44.0 | 111.0 0.992600 3.36 |
| [58,] | 0.092 | 30.0 | 123.0 0.995100 3.03 |
| [59,] | 0.048 | 50.0 | 147.0 0.997200 3.30 |
| [60,] | 0.035 | 17.0 | 151.0 0.991000 3.02 |
| [61,] | 0.044 | 25.0 | 78.0 0.993100 3.11 |
| [62,] | 0.038 | 31.0 | 122.0 0.992700 3.15 |
| [63,] | 0.064 | 29.0 | 120.0 0.993400 3.22 |
| [64,] | 0.040 | 27.0 | 124.0 0.990300 3.22 |

```
[65,]  0.041          81.0          174.0 0.992000 3.14
[66,]  0.046          30.0           96.0 0.992600 3.33
[67,]  0.050          21.0          105.0 0.996200 3.13
[68,]  0.056          48.0          244.0 0.995600 3.10
[69,]  0.061          50.5          238.5 0.995800 3.32
[70,]  0.063          31.0          201.0 0.996400 3.69
[71,]  0.054           9.0           72.0 0.994100 2.95
[72,]  0.046          30.0           96.0 0.992600 3.33
[73,]  0.050          21.0          105.0 0.996200 3.13
[74,]  0.043          31.0           87.0 0.989800 3.26
[75,]  0.042          20.0           69.0 0.991200 3.31
[76,]  0.064          26.0          103.0 0.996100 2.94
[77,]  0.060          21.0          105.0 0.994900 3.27
[78,]  0.053          34.0          114.0 0.992900 3.39
[79,]  0.050          51.0          166.0 0.998500 3.21
[80,]  0.063          47.0          164.0 0.994600 3.17
[81,]  0.047          42.0          207.0 0.996600 3.33
[82,]  0.045          54.0          155.0 0.997400 3.11
[83,]  0.044          52.0          152.0 0.997500 3.12
      sulphates   alcohol
 [1,]      0.45  8.800000
 [2,]      0.49  9.500000
 [3,]      0.44 10.100000
 [4,]      0.40  9.900000
 [5,]      0.40  9.900000
 [6,]      0.44 10.100000
 [7,]      0.47  9.600000
 [8,]      0.45  8.800000
 [9,]      0.49  9.500000
[10,]      0.45 11.000000
[11,]      0.56 12.000000
[12,]      0.53  9.700000
[13,]      0.63 10.800000
[14,]      0.52 12.400000
[15,]      0.67  9.700000
[16,]      0.55 11.400000
[17,]      0.36  9.600000
[18,]      0.53 11.300000
[19,]      0.50  9.500000
[20,]      0.39 12.800000
[21,]      0.35 11.000000
[22,]      0.48 10.500000
[23,]      0.51  9.300000
[24,]      0.47 10.000000
```

```
[25,]  0.50 10.400000
[26,]  0.44 10.000000
[27,]  0.53 10.500000
[28,]  0.49 11.600000
[29,]  0.71 12.300000
[30,]  0.53 10.000000
[31,]  0.40 10.200000
[32,]  0.44 10.800000
[33,]  0.37 10.200000
[34,]  0.42 12.800000
[35,]  0.35 10.000000
[36,]  0.28 11.200000
[37,]  0.36  8.600000
[38,]  0.36  8.600000
[39,]  0.36  9.400000
[40,]  0.34  9.400000
[41,]  0.46  9.800000
[42,]  0.56  9.500000
[43,]  0.56  9.500000
[44,]  0.53 10.000000
[45,]  0.52  9.800000
[46,]  0.52  9.800000
[47,]  0.46  9.800000
[48,]  0.48  9.800000
[49,]  0.44 11.700000
[50,]  0.58 11.000000
[51,]  0.46 10.900000
[52,]  0.35 10.900000
[53,]  0.52 11.000000
[54,]  0.50  9.600000
[55,]  0.36  8.900000
[56,]  0.38 10.200000
[57,]  0.34  9.900000
[58,]  0.46  8.600000
[59,]  0.36  8.900000
[60,]  0.34 10.500000
[61,]  0.38 10.200000
[62,]  0.46 10.300000
[63,]  0.54  9.100000
[64,]  0.49 12.600000
[65,]  0.42  9.800000
[66,]  0.64 10.700000
[67,]  0.35  9.500000
[68,]  0.51  9.000000
```

```
 [69,]      0.60  9.500000
 [70,]      0.71 10.000000
 [71,]      0.49  9.100000
 [72,]      0.64 10.700000
 [73,]      0.35  9.500000
 [74,]      0.37 12.700000
 [75,]      0.65 12.000000
 [76,]      0.56  9.300000
 [77,]      0.37  9.000000
 [78,]      0.77 10.600000
 [79,]      0.60  9.200000
 [80,]      0.42 10.000000
 [81,]      0.46  9.500000
 [82,]      0.45  8.700000
 [83,]      0.46  8.700000
 [ reached getOption("max.print") -- omitted 6380 rows ]
> cor(X)
                        type fixed.acidity volatile.acidity citric.acid
type                1.00000000   -0.48855152       -0.6533736  0.18589193
fixed.acidity       -0.48855152    1.00000000        0.2210657  0.32374422
volatile.acidity    -0.65337359    0.22106569        1.0000000 -0.37751178
citric.acid          0.18589193    0.32374422       -0.3775118  1.00000000
residual.sugar       0.34935757   -0.11344182       -0.1966773  0.14232362
chlorides           -0.51270521    0.29910392        0.3779950  0.03941180
free.sulfur.dioxide  0.47265344   -0.28348451       -0.3534023  0.13227063
total.sulfur.dioxide 0.70052093   -0.33054303       -0.4147289  0.19439801
density             -0.39143673    0.45971275        0.2721011  0.09706753
pH                  -0.32847382   -0.25112056        0.2601338 -0.32786021
sulphates           -0.48671509    0.30126342        0.2256557  0.05907023
alcohol              0.03509537   -0.09618987       -0.0395280 -0.01005581
                   residual.sugar   chlorides free.sulfur.dioxide
type                    0.3493576 -0.51270521          0.4726534
fixed.acidity           -0.1134418  0.29910392         -0.2834845
volatile.acidity        -0.1966773  0.37799504         -0.3534023
citric.acid              0.1423236  0.03941180          0.1322706
residual.sugar           1.0000000 -0.12881388          0.4034486
chlorides               -0.1288139  1.00000000         -0.1954276
free.sulfur.dioxide      0.4034486 -0.19542758          1.0000000
total.sulfur.dioxide     0.4956840 -0.27960212          0.7214763
density                  0.5514944  0.36310758          0.0251131
pH                      -0.2664806  0.04465296         -0.1451644
sulphates               -0.1856160  0.39623971         -0.1889472
alcohol                 -0.3591316 -0.25766379         -0.1794770
                   total.sulfur.dioxide     density          pH    sulphates
```

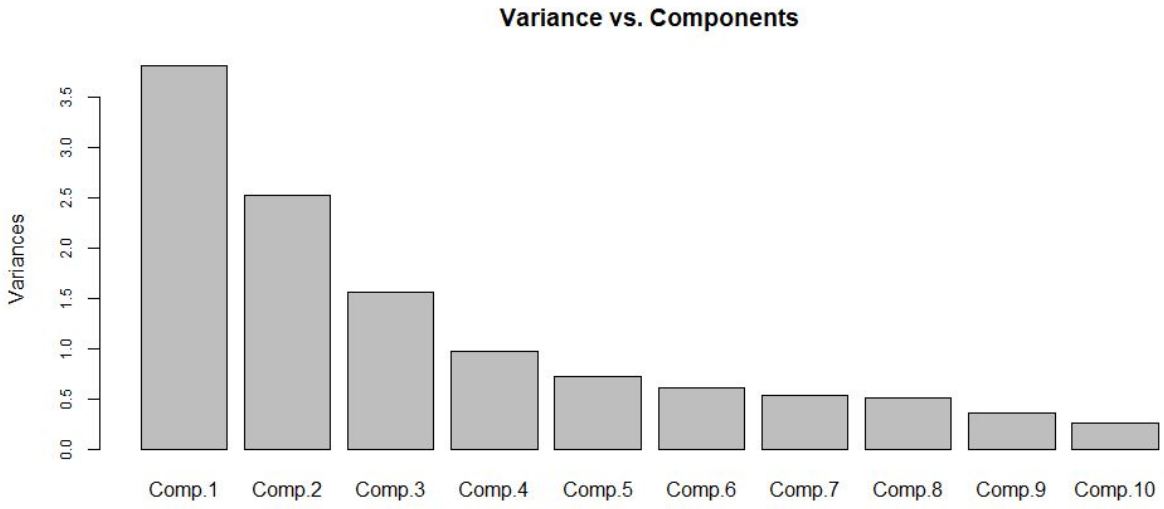
```
type                  0.70052093 -0.39143673 -0.32847382 -0.486715087
fixed.acidity          -0.33054303  0.45971275 -0.25112056  0.301263424
volatile.acidity       -0.41472888  0.27210115  0.26013376  0.225655656
citric.acid            0.19439801  0.09706753 -0.32786021  0.059070233
residual.sugar            0.49568401  0.55149436 -0.26648063 -0.185616000
chlorides              -0.27960212  0.36310758  0.04465296  0.396239710
free.sulfur.dioxide       0.72147633  0.02511310 -0.14516440 -0.188947245
total.sulfur.dioxide      1.00000000  0.03141942 -0.23720422 -0.275877734
density                0.03141942  1.00000000  0.01252482  0.260018537
pH                    -0.23720422  0.01252482  1.00000000  0.190864257
sulphates              -0.27587773  0.26001854  0.19086426  1.000000000
alcohol                -0.26438503 -0.68743209  0.12047258 -0.004116021
                      alcohol
type                0.035095371
fixed.acidity       -0.096189872
volatile.acidity    -0.039528000
citric.acid         -0.010055812
residual.sugar      -0.359131638
chlorides           -0.257663794
free.sulfur.dioxide -0.179477013
total.sulfur.dioxide -0.264385026
density             -0.687432085
pH                  0.120472577
sulphates           -0.004116021
alcohol             1.000000000
> #Perform PCA
> pcomp <- princomp(X,scores=TRUE,cor=TRUE)
> summary(pcomp)
Importance of components:
                          Comp.1    Comp.2    Comp.3     Comp.4     Comp.5
Standard deviation     1.9524492 1.5900901 1.2489927 0.98554833 0.85095661
Proportion of Variance 0.3176715 0.2106989 0.1299986 0.08094213 0.06034393
Cumulative Proportion  0.3176715 0.5283704 0.6583689 0.73931107 0.79965500
                          Comp.6     Comp.7     Comp.8     Comp.9    Comp.10
Standard deviation     0.7825512 0.73249466 0.70914084 0.59339505 0.50667695
Proportion of Variance 0.0510322 0.04471237 0.04190673 0.02934314 0.02139346
Cumulative Proportion  0.8506872 0.89539957 0.93730630 0.96664944 0.98804290
                          Comp.11     Comp.12
Standard deviation     0.345442058 0.155418877
Proportion of Variance 0.009944185 0.002012919
Cumulative Proportion  0.997987081 1.000000000
> loadings(pcomp)

Loadings:
```

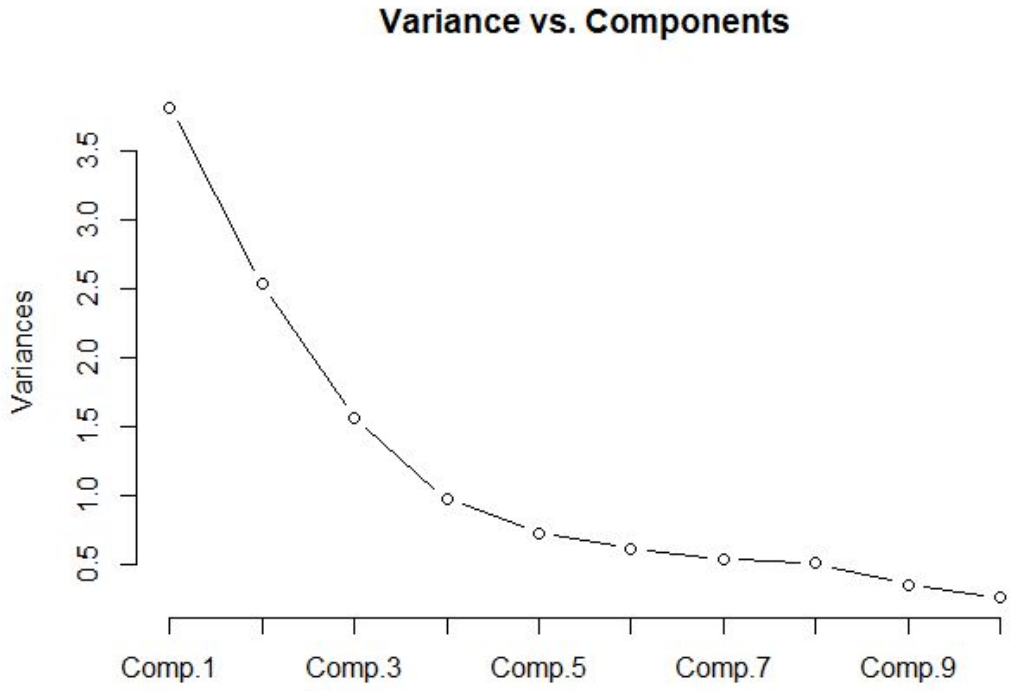
```
                  Comp.1 Comp.2 Comp.3 Comp.4 Comp.5 Comp.6 Comp.7 Comp.8
type                0.471                        0.109  0.162
fixed.acidity      -0.259 -0.271  0.449  0.166 -0.153 -0.218 -0.283 -0.328
volatile.acidity   -0.359        -0.288  0.217  0.151 -0.484 -0.239  0.188
citric.acid         0.113 -0.208  0.586 -0.267 -0.162  0.200 -0.340  0.354
residual.sugar      0.245 -0.399 -0.172  0.163 -0.355 -0.189  0.324  0.478
chlorides          -0.296 -0.240        -0.236  0.640  0.170         0.470
free.sulfur.dioxide  0.345 -0.171 -0.156 -0.362  0.177 -0.421 -0.359 -0.162
total.sulfur.dioxide 0.413 -0.193 -0.126 -0.211  0.141 -0.179 -0.141
density            -0.144 -0.561 -0.161        -0.296
pH                 -0.179  0.194 -0.449 -0.418 -0.440  0.292 -0.383  0.109
sulphates          -0.283 -0.121        -0.635 -0.103 -0.215  0.566 -0.241
alcohol                    0.476  0.252 -0.111 -0.208 -0.510         0.420
                  Comp.9 Comp.10 Comp.11 Comp.12
type                0.236  0.349   0.700   0.237
fixed.acidity      -0.173  0.470   0.219  -0.271
volatile.acidity    0.567 -0.118   0.236
citric.acid         0.345 -0.320
residual.sugar     -0.144               -0.454
chlorides          -0.246  0.277
free.sulfur.dioxide -0.403 -0.337   0.237
total.sulfur.dioxide 0.369  0.476  -0.535
density                            0.729
pH                  0.254   0.160  -0.160
sulphates           0.211          0.105
alcohol            -0.209  0.233  -0.135   0.317

                Comp.1 Comp.2 Comp.3 Comp.4 Comp.5 Comp.6 Comp.7 Comp.8 Comp.9
SS loadings     1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
Proportion Var  0.083  0.083  0.083  0.083  0.083  0.083  0.083  0.083  0.083
Cumulative Var  0.083  0.167  0.250  0.333  0.417  0.500  0.583  0.667  0.750
                Comp.10 Comp.11 Comp.12
SS loadings      1.000   1.000   1.000
Proportion Var   0.083   0.083   0.083
Cumulative Var   0.833   0.917   1.000
> #Visualize to find relevant components according to variance values
```

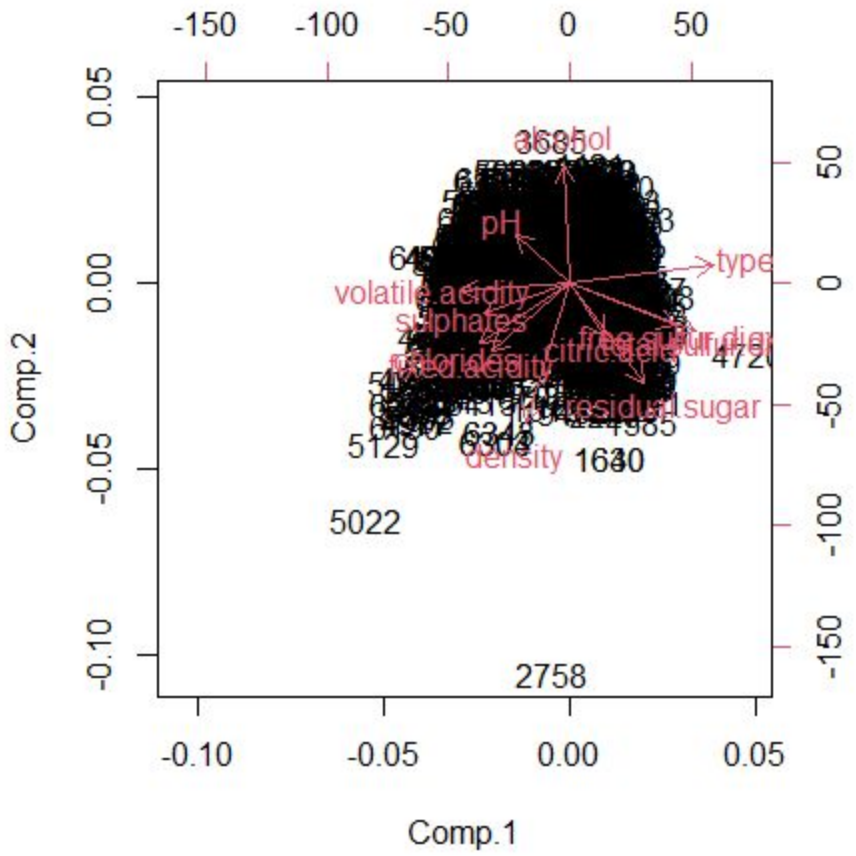
> plot(pcomp,main="Variance vs. Components",cex.axis=0.75)




> plot(pcomp,main="Variance vs. Components",t='l',cex.axis=0.75)



> biplot(pcomp)




> attributes(pcomp)
$names
[1] "sdev" "loadings" "center" "scale" "n.obs" "scores" "call"

$class
[1] "princomp"
> pcomp$scores[1:10,]

| | Comp.1 | Comp.2 | Comp.3 | Comp.4 | Comp.5 | Comp.6 |
|---|---|---|---|---|---|---|
| [1,] | 2.1756194 | -3.53575192 | -0.6950698 | 1.13989117 | -0.7724774 | -0.28700751 |
| [2,] | 0.2492494 | 0.55195491 | -0.3142272 | 0.02973331 | 0.1730222 | 1.44342286 |
| [3,] | 0.3788760 | -0.36530815 | 0.4808644 | 0.39203367 | -0.4986866 | 0.56635947 |
| [4,] | 1.7336115 | -0.93442864 | -0.3673014 | 0.06339402 | 0.2730116 | 0.06693123 |
| [5,] | 1.7336115 | -0.93442864 | -0.3673014 | 0.06339402 | 0.2730116 | 0.06693123 |
| [6,] | 0.3788760 | -0.36530815 | 0.4808644 | 0.39203367 | -0.4986866 | 0.56635947 |
| [7,] | 0.8659023 | -0.02358737 | -1.1592648 | 0.65595753 | 0.3337471 | 0.30716446 |
| [8,] | 2.1756194 | -3.53575192 | -0.6950698 | 1.13989117 | -0.7724774 | -0.28700751 |
| [9,] | 0.2492494 | 0.55195491 | -0.3142272 | 0.02973331 | 0.1730222 | 1.44342286 |
| [10,] | 0.5741955 | 0.55362902 | 1.2253469 | -0.02045094 | -0.1604755 | 0.42656019 |

```
          Comp.7      Comp.8      Comp.9     Comp.10     Comp.11     Comp.12
 [1,]  0.89440449  0.66814766 -0.27871146 -0.35400780 -0.10159689  0.03202005
 [2,] -0.03644417 -0.32503254  0.94065718  0.17841838 -0.06199936  0.14989236
 [3,] -0.50554692  0.07051367 -0.18171487  0.21118292  0.65642196 -0.18669917
 [4,] -0.49288999 -0.04123253 -0.35853411  0.45856631 -0.23826269 -0.05109274
 [5,] -0.49288999 -0.04123253 -0.35853411  0.45856631 -0.23826269 -0.05109274
 [6,] -0.50554692  0.07051367 -0.18171487  0.21118292  0.65642196 -0.18669917
 [7,]  0.61673649 -0.38996725  0.06979126  0.07469133  0.01733496  0.06378718
 [8,]  0.89440449  0.66814766 -0.27871146 -0.35400780 -0.10159689  0.03202005
 [9,] -0.03644417 -0.32503254  0.94065718  0.17841838 -0.06199936  0.14989236
[10,] -0.74216965 -0.31315467  0.03556993  0.53355668  0.06056121  0.26027262
>
```