

# Package ‘EnviroPRA’

October 12, 2022

**Type** Package

**Title** Environmental Probabilistic Risk Assessment Tools

**Version** 1.0

**Date** 2017-02-22

**Author** F. Barrio-Parra, with contributions from A. Dominguez-Castillo.

**Maintainer** Fernando Barrio-Parra <fernando.barrio@upm.es>

**Description** Methods to perform a Probabilistic Environmental Risk assessment from exposure to toxic substances - i.e. USEPA (1997) <<https://www.epa.gov/risk/guiding-principles-monte-carlo-analysis>> -.

**License** GPL

**Imports** MASS, kSamples, stats, fitdistrplus, truncdist

**NeedsCompilation** no

**Repository** CRAN

**Date/Publication** 2017-02-23 17:30:51

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EnviroPRA-package	<i>Environmental Probabilistic Risk Assessment Tools</i>
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## Description

A collection of functions employed in environmental risk assessment to model exposure to a toxicant and predicting health effects, allowing to characterize variability and uncertainty in risk estimations

## Details

The DESCRIPTION file:

```

Package:      EnviroPRA
Type:         Package
Title:        Environmental Probabilistic Risk Assessment Tools
Version:      1.0
Date:         2017-02-22
Author:       F. Barrio-Parra, with contributions from A. Dominguez-Castillo.
Maintainer:   Fernando Barrio-Parra <fernando.barrio@upm.es>
Description:  Methods to perform a Probabilistic Environmental Risk assessment from exposure to toxic substances - i.e. US
License:      GPL
Imports:      MASS, kSamples, stats, fitdistrplus, truncdist

```

Index of help topics:

```

AD              Dermal contact with chemicals in soil
ADboot          Dermal contact with chemicals in soil by
                bootstrap
AIR             Inhalation of airborne chemicals
AIRboot         Inhalation of airborne chemicals by bootstrap
DWIR            Chemical intake by Drinking Water
DWIRboot        Chemical intake by Drinking Water by bootstrap

```

EnviroPRA-package	Environmental Probabilistic Risk Assessment Tools
Fit_dist_parameter	Returns adjusted distribution parameters
HI	Hazard Index
HIdermal	Hazard Index for dermal contact
HIinhal	Hazard Index for inhalation of vapors
INH	Inhalation of resuspended soil particles
RISK	Risk
RISKInhal	Risk for inhalation of vapors
RISKdermal	Risk for dermal contact
SIR	Chemical intake by accidental soil ingestion
SIRboot	Chemical intake by accidental soil ingestion by bootstrap
VI	Chemical intake by ingestion of vegetables
VIboot	Chemical intake by ingestion of vegetables by bootstrap
condition	p-value significance checking function
extr_par	Extracts the fitted distribution parameters to be introduced in other function
fit_dist_test	Summary of Godness-of-fit tests
plot_fit_dist	Graphical representation of data fitting to a distribution
random_number_generator	
	Random number generator
sampler	Execute sampling with replacement
sig	Significance level cheking function

~~ An overview of how to use the package, including the most important functions ~~

### Author(s)

F. Barrio-Parra, with contributions from A. Dominguez-Castillo.

Maintainer: Fernando Barrio-Parra <fernando.barrio@upm.es>

### Examples

```
##### Performs Deterministic Environmental Risk Assessment #####

# Example of dermal contact with a chemical in swimming water

# Estimate the dermal absorbed dose during swimming in waters with a carcinogenic chemical
# (water concentration of 250 mg/m^3)

DWIR ( CW = 250)

# For a systemic effect:

DWIR ( CW= 250, AT=24*365)
```

```
# Specifying all the parameters for the carcinogenic case
I = DWIR ( CW=250, IR=1.5, EF = 300, ED = 24, BW = 85)

# Chemical Slope factor
SFAs = 1.5

# Dermal Absorption Factor
ABSAs = 3e-02

# Gastrointestinal Absorption Factor
GIAs = 1

# Risk Estimation
RISKdermal (AD = I, SF = SFAs, GI = GIAs)

#### Perform a test to assess the fitness of a theoretical distribution to empirical data ####
set.seed(123)
a <- rnorm(n=100, mean =1.5, sd = 0.25)
b <- rnorm(n = 15, mean = 300, sd = 15)

fit_dist_test(a)
fit_dist_test(b)

# Graphical representation of data fitting to a distribution
plot_fit_dist(a, "norm")
plot_fit_dist(b, "norm")

#### Perform a Probabilistic Environmental Risk Assessment ####
Fita <- Fit_dist_parameter(a)
Fitb <- Fit_dist_parameter(b)

IRr <-random_number_generator(n = 10000, Fited = Fita,
                             dist = "norm", a =0.8, b = 2.1)

EFr <-random_number_generator(n = 10000, Fited = Fitb,
                             dist = "norm", a =250, b = 330)

I = DWIR ( CW=250, IR=IRr, EF = EFr, ED = 24, BW = 85)

# Risk Estimation
```

```
Risk <- RISKdermal (AD = I, SF = SFAs, GI = GIAs)
hist (Risk)
quantile (Risk, c (0.05, 0.25, 0.5, 0.75, 0.95))
```

AD

*Dermal contact with chemicals in soil***Description**

Estimates the Absorbed dose [mg/Kg\*day] of chemicals through dermal contact with a soil

**Usage**

AD(CS = 1, SA = 2800, AF = 0.2, ABS = 0.001, EF = 350, ED = 24, BW = 70, AT = 365 \* 70)

**Arguments**

CS	Chemical concentration in soil [mg/Kg]
SA	Skin surface area available for contact [cm <sup>2</sup> ]
AF	Skin adherence factor [mg/cm <sup>2</sup> ]
ABS	Absorption factor (Chemical specific) [-]
EF	Exposure frequency [day/yr]
ED	Exposure duration [yr]
BW	Body weight [Kg]
AT	Averaging time [day] (Note that for No carcinogenic effects AT should be equal to 365*ED)

**Value**

Chemical Absorbed dose [mg/Kg\*day]

**Author(s)**

F. Barrio-Parra

**References**

US Environmental Protection Agency, 2011. Exposure Factors Handbook: 2011 Edition. U.S. Environmental Protection Agency, EPA/600/R-(September), pp 1466.

**Examples**

```

## Estimated absorbed dose for the estimation of carcinogenic effects using
# the default variables (EPA 2011) for a chemical soil concentration of
# 0.2 mg/Kg

AD( CS=0.2)

# For a systemic effect:

AD( CS=0.2, AT=24*365)

# Specifying all the parameters for the carcinogenic case

AD( CS=0.2, SA=2300, AF=0.25, ABS=0.01, EF=150, ED=10, BW=80)

```

ADboot

*Dermal contact with chemicals in soil by bootstrap***Description**

Dermal contact with chemicals in soil by bootstrap

**Usage**

ADboot(n, CS, SA, AF, ABS, EF, ED, BW, AT)

**Arguments**

n	Output vector length
CS	Chemical concentration in soil [mg/Kg]
SA	Skin surface area available for contact [cm <sup>2</sup> ]
AF	Skin adherence factor [mg/cm <sup>2</sup> ]
ABS	Absorption factor (Chemical specific) [-]
EF	Exposure frequency [day/yr]
ED	Exposure duration [yr]
BW	Body weight [Kg]
AT	Averaging time [day] (Note that for No carcinogenic effects AT should be equal to 365*ED)

**Value**

Chemical Absorbed dose [mg/Kg\*day]

**Author(s)**

F. Barrio-Parra

**Examples**

```
# Carcinogenic effects

c <- rnorm( n= 10, mean = 0.2, sd = 0.05 )

b <- rnorm( n= 100, mean = 20, sd = 5 )

ADboot (n = 1000, SA=2300, AF=0.25, ABS=0.01, CS = c, BW = b, ED = 10, EF = 250)
```

AIR

*Inhalation of airborne chemicals***Description**

Estimates the Intake rate by inhalation of airborne chemicals (vapor phase) [mg/Kg\*day]

**Usage**

```
AIR(CA = 1, IR = 20, ET = 24, EF = 350, ED = 24, BW = 70, AT = 365 * 70)
```

**Arguments**

CA	Chemical concentration in air [mg/m <sup>3</sup> ]
IR	Inhalation Rate [m <sup>3</sup> /hour]
ET	Exposure time [hours/day]
EF	Exposure frequency [day/yr]
ED	Exposure duration [yr]
BW	Body weight [Kg]
AT	Averaging time [day] (Note that for No carcinogenic effects AT should be equal to 365*ED)

**Value**

Intake rate by inhalation of airborne chemicals (vapor phase) I [mg/Kg\*day]

**Author(s)**

F. Barrio-Parra

**References**

US Environmental Protection Agency, 2011. Exposure Factors Handbook: 2011 Edition. U.S. Environmental Protection Agency, EPA/600/R-(September), pp 1466.

**Examples**

```

## Estimated absorbed dose for the estimation of carcinogenic effects using
# the default variables (EPA 2011) for a chemical air concentration
# of 0.2 mg/m^3

AIR ( CA=0.2)

# For a systemic effect:

AIR ( CA=0.2, AT=24*365)

# Specifying all the parameters for the carcinogenic case

AIR ( CA=0.2, IR=25, ET = 24, EF = 300, ED = 24, BW = 85)

```

---

AIRboot

*Inhalation of airborne chemicals by bootstrap*


---

**Description**

Estimates the Intake rate by inhalation of airborne chemicals (vapor phase) [mg/Kg\*day]

**Usage**

AIRboot(n, CA, IR, ET, EF, ED, BW, AT)

**Arguments**

n	Output vector length
CA	Chemical concentration in air [mg/m <sup>3</sup> ]
IR	Inhalation Rate [m <sup>3</sup> /hour]
ET	Exposure time [hours/day]
EF	Exposure frequency [day/yr]
ED	Exposure duration [yr]
BW	Body weight [Kg]
AT	Averaging time [day] (Note that for No carcinogenic effects AT should be equal to 365*ED)

**Value**

Intake rate by inhalation of airborne chemicals (vapor phase) I [mg/Kg\*day]

**Author(s)**

F. Barrio-Parra

**Examples**

```
# Carcinogenic effects
c <- rnorm( n= 10, mean = 0.2, sd = 0.05 )
b <- rnorm( n= 100, mean = 20, sd = 5 )
AIRboot (n = 1000, CA=c, IR=25, ET = 24, EF = 300, ED = 24, BW = b)
```

---

condition	<i>p-value significance checking function</i>
-----------	---

---

**Description**

Auxiliar function to check p-value significance

**Usage**

```
condition(n)
```

**Arguments**

n	p-value
---	---------

**Value**

Return "Significant" or "Not-significant"

**Examples**

```
condition ( 0.001)
condition (0.1)
```

---

DWIR	<i>Chemical intake by Drinking Water</i>
------	--

---

**Description**

Estimates the chemical Intake rate by Drinking Water [mg/Kg\*day]

**Usage**

```
DWIR(CW = 1, IRW = 2, EF = 350, ED = 24, BW = 80, AT = 365 * 70)
```

**Arguments**

CW	Chemical concentration in water [mg/L]
IRW	Water Ingestion Rate [L/Day]
EF	Exposure frequency [day/yr]
ED	Exposure duration [yr]
BW	Body weight [Kg]
AT	Averaging time [day] (Note that for No carcinogenic effects AT should be equal to 365*ED)

**Value**

Chemical intake rate by drinking water I [mg/Kg\*day]

**Author(s)**

F. Barrio-Parra

**References**

US Environmental Protection Agency, 2011. Exposure Factors Handbook: 2011 Edition. U.S. Environmental Protection Agency, EPA/600/R-(September), pp 1466.

**Examples**

```
# Estimate the dermal absorbed dose during swimming in waters with a carcinogenic chemical
# (water concentration of 250 mg/m^3)
```

```
DWIR ( CW = 250)
```

```
# For a systemic effect:
```

```
DWIR ( CW= 250, AT=24*365)
```

```
# Specifying all the parameters for the carcinogenic case
```

```
DWIR ( CW=250, IR=1.5, EF = 300, ED = 24, BW = 85)
```

---

DWIRboot

*Chemical intake by Drinking Water by bootstrap*

---

**Description**

Estimates the chemical Intake rate by Drinking Water [mg/Kg\*day]

**Usage**

DWIRboot(n, CW, IRW, EF, BW, ED, AT)

**Arguments**

n	Output vector length
CW	Chemical concentration in water [mg/L]
IRW	Water Ingestion Rate [L/Day]
EF	Exposure frequency [day/yr]
BW	Body weight [Kg]
ED	Exposure duration [yr]
AT	Averaging time [day] (Note that for No carcinogenic effects AT should be equal to 365*ED)

**Value**

Chemical intake rate by drinking water I [mg/Kg\*day]

**Author(s)**

F. Barrio-Parra

**Examples**

```
# Carcinogenic effects

c <- rnorm( n= 10, mean = 250, sd = 15 )

b <- rnorm( n= 100, mean = 20, sd = 5 )

DWIRboot (n = 1000, CW=c, IR=1.5, EF = 300, ED = 24, BW = b)
```

---

extr_par	<i>Extracts the fitted distribution parameters to be introduced in other function</i>
----------	---

---

**Description**

Auxiliar function

**Usage**

```
extr_par(x, dist)
```

**Arguments**

x	List of parameters obtained by the application of the Fit_dist_parameter function
dist	Name of the distribution we would like to stract the parameters ("norm", "lnorm", "geom", "exp", "pois", "gamma", "cauchy", "logis", "weibull", "nbinom", "beta", "chisq", "t", "f")

**Author(s)**

F. Barrio-Parra

**Examples**

```
a <- rnorm(n=100, mean =10, sd = 1)
b <- Fit_dist_parameter(a)
extr_par(x = b, dist ="norm")
```

---

Fit_dist_parameter	<i>Returns adjusted distribution parameters</i>
--------------------	---

---

**Description**

Returns the distribution parameters adjusted for by maximum likelihood (mle) for the following distributions: "normal","log-normal","geometric","exponential","Poisson", "cauchy" , "logistic" and "weibull"

**Usage**

```
Fit_dist_parameter(x)
```

**Arguments**

x	A numeric vector of length at least one containing only finite values (non-censored data)
---	---

**Value**

normal	Fitted Mean and sd for a normal distribution
'log-normal'	Fitted Meanlog and sdlog for a log-normal distribution
geometric	Fitted prob for a geometric distribution
exponential	Fitted rate for a exponential distribution
Poisson	Fitted lambda for a exponential distribution
cauchy	Fitted location and scale for a Cauchy distribution
logistic	Fitted location and scale for a Logistic distribution
weibull	Fitted shape and scale for a weibull distribution

**Author(s)**

F. Barrio-Parra

**See Also**

Function `fitdistr` in Library (MASS)

**Examples**

```
a <- rnorm(n=100, mean =10, sd = 1)
b <- Fit_dist_parameter(a)
# Examples of result extraction
b$normal
b$weibull
```

---

<code>fit_dist_test</code>	<i>Summary of Godness-of-fit tests</i>
----------------------------	--

---

**Description**

Returns a data frame with the summary of Fiting distribution tests for the following distributions: "normal","log-normal","geometric","exponential","Poisson", "cauchy" , "logistic" and "weibull".

The considered Godness-of-fit tests are: Bayesian Information Criterium (BIC), Akaike Information Criterium (AIC), Kolmogorov-Smirnov test and Anderson-Darling test.

**Usage**

```
fit_dist_test(x)
```

**Arguments**

`x` A numeric vector of length at least one containing only finite values

**Value**

Distribution	Name of the tested distribution
BayesianIC	Bayesian Information Criterium (BIC)
AkaikeIC	Akaike Information Criterium (AIC)
Kol-SmirD	The value of the Kolmogorov-Smirnov test statistic
Kol-SmirPvalue	The value of the Kolmogorov-Smirnov test p-value
Significance KS	A column to check the significance of the Kolmogorov-Smirnov test
And-Dar1	The value of the nderson-Darling test statistic

And-DarIPvalue

The value of the Anderson-Darling test p-value

Significance AD

A column to check the significance of the Anderson-Darling test

### Author(s)

F. Barrio-Parra

### See Also

ad.test library(kSamples), AIC library(stats), BIC library(stats), ks.test library(stats),

### Examples

```
set.seed(123)

a <- rnorm(n=100, mean =10, sd = 1)

fit_dist_test(a)

b<- rexp(n = 100,rate = 1)

fit_dist_test(b)
```

---

HI

*Hazard Index*

---

### Description

Returns the Hazard Index (non carcinogenic effects)

### Usage

```
HI(I, RFD)
```

### Arguments

I	Intake Rate [mg/Kg*day]
RFD	Reference dose [mg/Kg*day]

### Value

Hazard Index [-]

### Author(s)

F. Barrio-Parra

**Examples**

```
# Assessing if there is systemic risk for an adult receptor that drinks water with 1000 ug/L
# of hexachlorobence (Reference Dose (IRIS data base) = 8e-04 [mg/Kg*day]) in a residential
# scenario (default EPA Maximum Reasonable Exposure parameters)
```

```
HI (I = DWIR( CW=1, AT=24*365), RFD = 8e-04)
```

---

HI <sub>dermal</sub>	<i>Hazard Index for dermal contact</i>
----------------------	--

---

**Description**

Returns the Hazard Index for dermal exposure with chemicals (non carcinogenic effects)

**Usage**

```
HIdermal(AD, RFD, GI)
```

**Arguments**

AD	Absorbed dose [mg/Kg*day]
RFD	Reference dose [mg/Kg*day]
GI	Gastrointestinal Absorption factor (chemical specific) [-]

**Value**

Hazard Index [-]

**Author(s)**

F. Barrio-Parra

**See Also**

AD EnviroPRA

**Examples**

```
# Assess if there is non-carcinogenic risk for an adult through dermal
# contact exposed to a soil that contains 45 mg/Kg of As in a residential
# scenario (default EPA Maximum Reasonable Exposure parameters)
```

```
RfDAs = 3e-04
```

```
# Dermal Absorption Factor
```

```
ABSAs = 3e-02
# Gastrointestinal Absorption Factor
GIAs = 1
I = AD (CS = 45, ABS = ABSAs, AT= 24*365)
HIdermal (AD = I, RFD = RfDAs, GI = GIAs)
```

---

HIinhal

*Hazard Index for inhalation of vapors*

---

### Description

Returns the Hazard Index (systemic effects) for inhalation of vapors

### Usage

```
HIinhal(INH, RFC)
```

### Arguments

INH	Inhaled dose (mg/m <sup>3</sup> )
RFC	Reference concentration (mg/m <sup>3</sup> )

### Value

Hazard Index (non carcinogenic effects) [-]

### Author(s)

F. Barrio-Parra

### See Also

AIR EnviroPRA

### Examples

```
# Assess if there is systemic risk for the exposure of an adult
# (Reasonable Maximum Exposure) to a Toluene air concentration of 2 mg/ m^3

HIinhal (INH = AIR (CA = 2, AT = 365*24), RFC = 5)
```

---

 INH *Inhalation of resuspended soil particles*


---

**Description**

Estimates the Intake rate of chemicals by inhalation of resuspended soil particles [mg/Kg\*day]

**Usage**

INH(C = 10, EF = 350, ED = 24, PEF = 1.36^9, AT = 365 \* ED)

**Arguments**

C	Concentration of chemicals in soil(mg/kg)
EF	Exposure frequency (day/year)
ED	Exposure duration (years)
PEF	Particle emission factor meaning resuspended particles(m^3/kg)
AT	Averaging time [day] (Note that for No carcinogenic effects AT should be equal to 365*ED)

**Value**

Chemical intake rate by inhalation of soil particles I [mg/Kg\*day]

**Author(s)**

F. Barrio-Parra

**References**

US Environmental Protection Agency, 2011. Exposure Factors Handbook: 2011 Edition. U.S. Environmental Protection Agency, EPA/600/R-(September), pp 1466.

**Examples**

```
# Estimated dose for the estimation of carcinogenic effects due to the
# inhalation of soil particles that contains 45 mg/Kg of As in a residential
# scenario (default EPA Maximum Reasonable Exposure parameters)
```

```
INH(C= 45, AT = 365*70)
```

```
# For non-carcinogenic effects:
```

```
INH(C= 45)
```

---

plot_fit_dist	<i>Graphical representation of data fitting to a distribution</i>
---------------	---

---

**Description**

A function to help assessing the distribution that best fit a data vector

**Usage**

```
plot_fit_dist(x, dist)
```

**Arguments**

x	A numeric vector of length at least one containing only finite values (values must be $\geq 0$ )
dist	Character vector indicating the distribution to be plotted: "norm", "lnorm", "geom", "exp", "pois", "cauchy", "logis", "weibull"

**Value**

Returns: Empirical and theoretical density plots, Empirical and theoretical CDFs, Q-Q plot, P-P plot

**Author(s)**

F. Barrio-Parra

**See Also**

plotdist from Library (fitdstrplus)

**Examples**

```
set.seed(123)
a <- rnorm(n = 100, mean = 10, sd = 1)
plot_fit_dist(a, "norm")
```

---

`random_number_generator`*Random number generator*

---

**Description**

Return a vector of n random numbers following a truncated distribution (dist) in agreement with a fitted parameters "Fited"

**Usage**

```
random_number_generator(n, Fited, dist, a, b)
```

**Arguments**

n	The number of desired generated numbers
Fited	A list containing the parameters obtained by application of Fit_dist_parameter
dist	Character vector indicating the distribution to be applied: "norm", "lnorm", "geom", "exp", "pois", "cauchy", "logis", "weibull"
a	Truncation Lower limit
b	Truncation Upper limit

**Value**

A vector of n random numbers

**Author(s)**

F. Barrio-Parra

**See Also**

Fit\_dist\_parameter

**Examples**

```
set.seed(123)
a <- rnorm(n = 100, mean = 10, sd = 1)
Fit <- Fit_dist_parameter(a)

b <- random_number_generator(n = 10000, Fited = Fit,
                             dist = "norm", a = 8, b = 12)

par(mfrow=c(2,1))

hist(a,xlim= c(7,14))
hist(b,xlim= c(7,14))
```

---

 RISK
 

---

*Risk***Description**

Returns the Risk estimation (carcinogenic effects)

**Usage**

RISK(I, SF)

**Arguments**

I	Intake Rate [mg/Kg*day]
SF	Slope Factor [(mg/Kg*day) <sup>-1</sup> ] (chemical specific)

**Value**

Risk [-]

**Author(s)**

F. Barrio-Parra

**Examples**

```
# Assessing if there is carcinogenic risk for an adult receptor that drinks water with 1000 ug/L
# of hexachlorobence (Oral Slope Factor (IRIS data base) = 1.6 [mg/Kg*day]-1) in a residential
# scenario (default EPA Maximum Reasonable Exposure parameters)
```

```
RISK (I = DWIR( CW=1), SF = 1.6)
```

---

 RISKdermal
 

---

*Risk for dermal contact***Description**

Returns the Risk for dermal exposure with chemicals (carcinogenic effects)

**Usage**

RISKdermal(AD, SF, GI)

**Arguments**

AD	Absorbed dose [mg/Kg*day]
SF	Slope Factor [(mg/Kg*day) <sup>-1</sup> ] (chemical specific)
GI	Gastrointestinal Absorption factor (chemical specific) [-]

**Value**

Risk [-]

**Author(s)**

F. Barrio-Parra

**See Also**

AD EnviroPRA

**Examples**

```
# Assess if there is carcinogenic risk for an adult thorough dermal
# contact exposed to a soil that contains 45 mg/Kg of As in a residential
# scenario (default EPA Maximum Reasonable Exposure parameters)
```

```
SFAs = 1.5
```

```
# Dermal Absorption Factor
```

```
ABSAs = 3e-02
```

```
# Gastrointestinal Absorption Factor
```

```
GIAAs = 1
```

```
I = AD (CS = 45, ABS = ABSAs)
```

```
RISKdermal (AD = I, SF = SFAs, GI = GIAAs)
```

---

RISKInhal

*Risk for inhalation of vapors*

---

**Description**

Returns the risk (carcinogenic effects) for inhalation of vapors

**Usage**

RISKInhal(URi, I)

**Arguments**

URi                    Inhalation Unit risk [(ug/m<sup>3</sup>)<sup>-1</sup>]  
 I                        Inhaled dose (mg/m<sup>3</sup>)

**Value**

Risk [-]

**Examples**

```
# Assess if there is cancer risk for the exposure of an adult
# (Reasonable Maximum Exposure) to a benzene air concentration of 2 mg/ m^3

RISKInhal ( I = AIR (CA = 2), URi = 7.8e-06)
```

---

sampler

*Execute sampling with replacement*

---

**Description**

Auxiliar function

**Usage**

sampler(n, a)

**Arguments**

n                        Number of sampling iterations  
 a                        data vector

**Value**

Resampled vector of length n

**Author(s)**

F. Barrio-Parra

**Examples**

```
a <- rnorm (n = 20, mean = 0, sd = 1)

b <- sampler (n = 100, a = a)
```



**Value**

Chemical intake rate by soil ingestion I [mg/Kg\*day]

**Author(s)**

F. Barrio-Parra

**References**

US Environmental Protection Agency, 2011. Exposure Factors Handbook: 2011 Edition. U.S. Environmental Protection Agency, EPA/600/R-(September), pp 1466.

**Examples**

```
# Ingestion rate for a children weighing 20 Kg who ingest 200 mg
# of soil every day, 250 days per year during 10 years. 95-UCL of
# Arsenic in soil is 25 mg/Kg
```

```
# Carcinogenic effects
```

```
SIR ( CS = 25, BW = 20, IR = 200, ED = 10, EF = 250)
```

```
# Systemic effects
```

```
SIR ( CS = 25, BW = 20, IR = 200, ED = 10, EF = 250, AT = 365*10)
```

---

SIRboot

*Chemical intake by accidental soil ingestion by bootstrap*

---

**Description**

Estimates the chemical Intake rate by accidental soil ingestion [mg/Kg\*day]

**Usage**

```
SIRboot(n, CS, IR, FI, EF, ED, BW, AT)
```

**Arguments**

n	Output vector length
CS	Chemical concentrtrion in soil [mg/Kg]
IR	Soil Ingestion Rate [mg/Day]
FI	Fraction ingested from contaminated source [-]
EF	Exposure frequency [day/yr]
ED	Exposure duration [yr]
BW	Body weight [Kg]
AT	Averaging time [day] (Note that for No carcinogenic effects AT should be equal to 365*ED)

**Value**

Chemical intake rate by soil ingestion I [mg/Kg\*day]

**Examples**

```
# Carcinogenic effects
c <- rnorm( n= 10, mean = 22, sd = 2 )
b <- rnorm( n= 100, mean = 20, sd = 5 )
SIRboot (n = 1000, CS = c, BW = b, IR = 200, ED = 10, EF = 250)
```

VI

*Chemical intake by ingestion of vegetables***Description**

Estimates the chemical Intake rate by ingestion of contaminated fruits and vegetables [mg/Kg\*day]

**Usage**

VI(CF = 1, IR = 210, FI = 1, EF = 350, ED = 24, BW = 80, AT = 365 \* 70)

**Arguments**

CF	Chemical concentration in food [mg/Kg]
IR	Vegetables Ingestion Rate [g / Kg * Day]
FI	Fraction ingested from contaminated source [-]
EF	Exposure frequency [day/yr]
ED	Exposure duration [yr]
BW	Body weight (kg)
AT	Averaging time [day] (For No carcinogenic effects AT = 365*ED)

**Value**

Chemical intake rate by vegetable ingestion I [mg/Kg\*day]

**Author(s)**

F. Barrio-Parra

**References**

US Environmental Protection Agency, 2011. Exposure Factors Handbook: 2011 Edition. U.S. Environmental Protection Agency, EPA/600/R-(September), pp 1466.

**Examples**

```
# Assess the chemical intake by an adult that eats lettuce with a concentration of 2 mg/ Kg
# in a maximum reasonable exposure scenario for non- carcinogenic effects
```

```
VI (CF = 2, AT = 365*24)
```

---

 VIboot

---

*Chemical intake by ingestion of vegetables by bootstrap*


---

**Description**

Estimates the chemical Intake rate by ingestion of contaminated fruits and vegetables [mg/Kg\*day]

**Usage**

```
VIboot( n, CF, IR, FI, EF, ED, BW, AT)
```

**Arguments**

n	Output vector length
CF	Chemical concentration in food [mg/Kg]
IR	Vegetables Ingestion Rate [g / Kg * Day]
FI	Fraction ingested from contaminated source [-]
EF	Exposure frequency [day/yr]
ED	Exposure duration [yr]
BW	Body Weight [Kg]
AT	Averaging time [day] (For No carcinogenic effects AT = 365*ED)

**Value**

A vector of Chemical intake rate by vegetable ingestion I [mg/Kg\*day]

**Examples**

```
# Assess the chemical intake by an adult that eats lettuce with a concentration of 2 mg/ Kg of a
# chemical with non- carcinogenic effects in a maximum reasonable exposure scenario
# Figure out 10 data of Chemical concentration following a normal distribution (mean = 2, sd= 2)
# and 100 Body weight data that follow a normal distribution (mean = 70, sd = 15)
```

```
c <- rnorm( n= 10, mean = 2, sd = 2 )
```

```
b <- rnorm( n= 100, mean = 70, sd = 5 )
```

```
VIboot (n = 1000, CF = c, BW = b, AT = 365*24)
```

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