

# Persistent organic pollutants in agricultural soil and prevention of leakage to the surroundings

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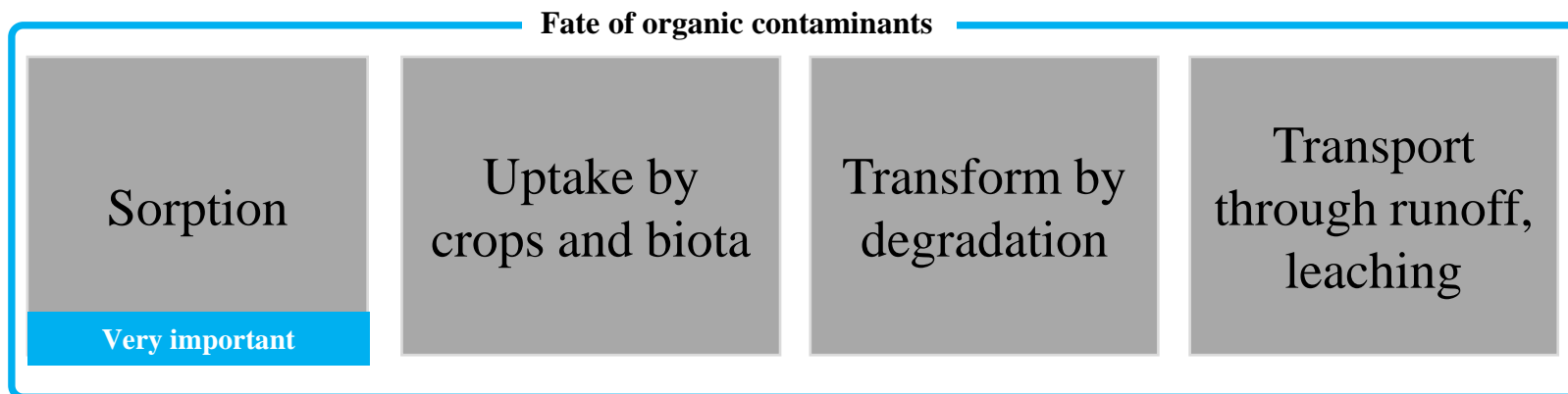
*Beijing Normal University, China*

SNOWMAN NETWORK  
Knowledge for sustainable soils



# Organic contaminants

- 1/3 of the chemicals in the technosphere is used on a regular basis in the society
- Some of them ends up in the environment in one way or the other
- Unintentional spreading
  - Emissions and leakage from the industry
  - Every day use of products
- Intentional spreading
  - Herbicides and pesticides



# ECOSOM SOIL ORGANIC MATTER AS A KEY FACTOR IN THE PROVISION OF SOIL ECOSYSTEM SERVICES

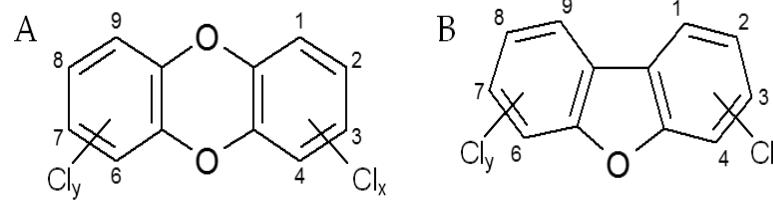
*Oct 2011 – Feb 2015*



*Coordinated by INRA, France: Sabine Houot and Laure Vieuble Gonod*



# POPs



- Included compounds

- Polychlorinated dibenzo-*p*-dioxins and dibenzofurans (**PCDD/F**)
- Polybrominated dibenzo-*p*-dioxins and dibenzofurans (**PBDD/F**)
- Polychlorinated biphenyls (**PCB**)
- Polybrominated diphenylethers (**PBDE**)

Toxic concentration is used to be able to compare the toxic content of different samples

$$\text{TEQ} = \sum_{n_1} [\text{PCDD}_i \times \text{TEF}_i] + \sum_{n_2} [\text{PCDF}_i \times \text{TEF}_i] + \sum_{n_3} [\text{PCB}_i \times \text{TEF}_i]$$

TEF= toxic equivalent factor

- Congener: individual molecules with different number of Cl-atoms (1 up to 8) in different positions
  - 75 dioxin congeners
  - 135 furan congeners
  - 17 congeners are toxic, they have Cl-atoms in position 2,3,7 and 8
- Homolog: congeners with the same number of Cl-atoms constitute a homolog.

# Transfer of POPs from amendments to agricultural soils



## Ultuna field site

- Established in 1956 by SLU close to Uppsala
- Small plots (2 m × 2 m)
- The amendment were worked in to the top 20 cm by spade
- Addition of sewage sludge 2 tC/ha
- Samples for analysis of organic pollutants were from 2013



## Lanna field site

- Established in 1996 at Lanna agricultural research station in Western Sweden
- Plots of 100 m<sup>2</sup>
- The amendments were applied through ploughing to a maximum depth of 25 cm
- Addition of sewage sludge 4 tC/ha corresponding to 12 times the allowed amount according to Swedish regulations
- Samples for analysis of organic pollutants were from 2012

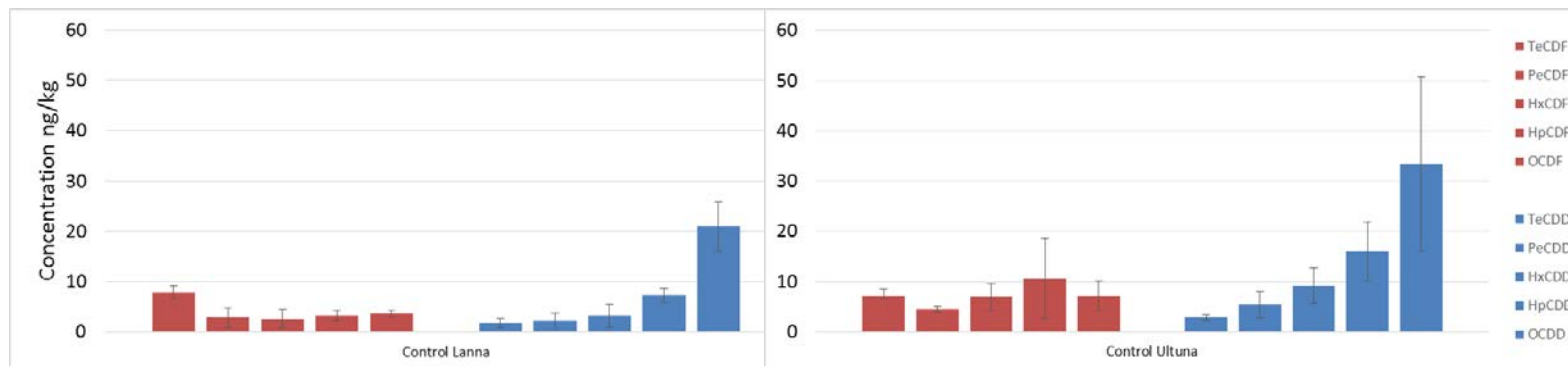
*Samples from the Swedish field sites were provided from SLU  
Thomas Kätterer and Gunnar Börjesson*

# Results – Control soils



- Background concentrations due to depositions from air and precipitation
- More dioxins than furans
- Highest contribution of the least toxic congeners OCDD

Unit: ng/kg	Control Lanna	Control Ultuna
<b>WHO-TEQ</b>	1.0 ± 0.4	2.5 ± 0.8
<b>Total amount PCDF</b>	20 ± 1	36 ± 14
<b>Total amount PCDD</b>	36 ± 5	67 ± 24

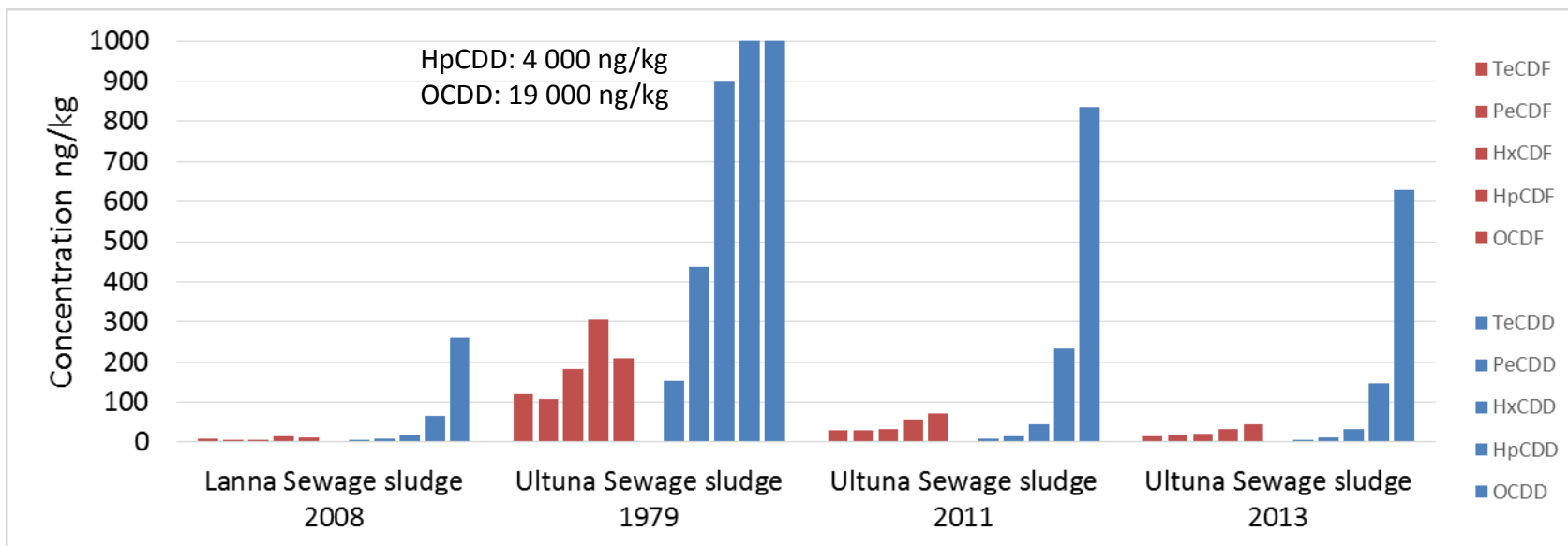


# Results - Content in amendment

Potential increase when amended with sewage sludge since the start

- Ultuna: Total concentration = 1 600 ng/kg  
Toxic concentration = 3.1 ng/kg
- Lanna: Total concentration = 10 ng/kg  
Toxic concentration = 0.04 ng/kg

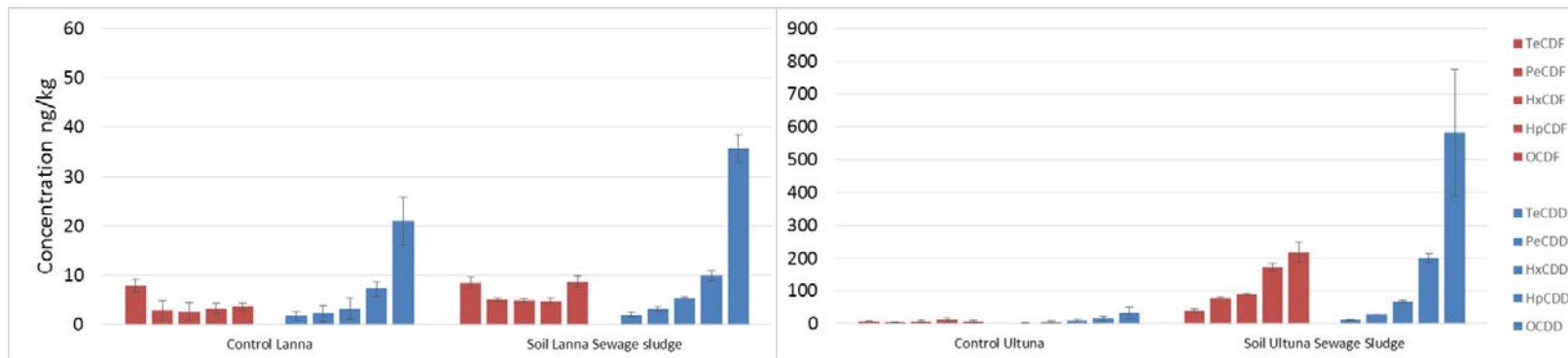
Sewage Sludge Unit ng/kg	Lanna 2008	Ultuna 1979	Ultuna 2011	Ultuna 2013
WHO-TEQ	1.6	48	20	14
Total concentration PCDF	50	930	220	130
Total concentration PCDD	360	25 000	1 100	820



# Results – Concentrations in amended soils

Unit ng/kg	Control Lanna	Soil Lanna	Control Ultuna	Soil Ultuna
WHO-TEQ	1.0 ± 0.4	1.6 ± 0.1	2.5 ± 0.8	22 ± 2
Total concentration PCDF	20 ± 1	32 ± 4	36 ± 14	600 ± 40
Total concentration PCDD	36 ± 5	56 ± 4	70 ± 25	890 ± 200

Adding amendments with high concentrations of PCDD/F increased the concentration in the soil.





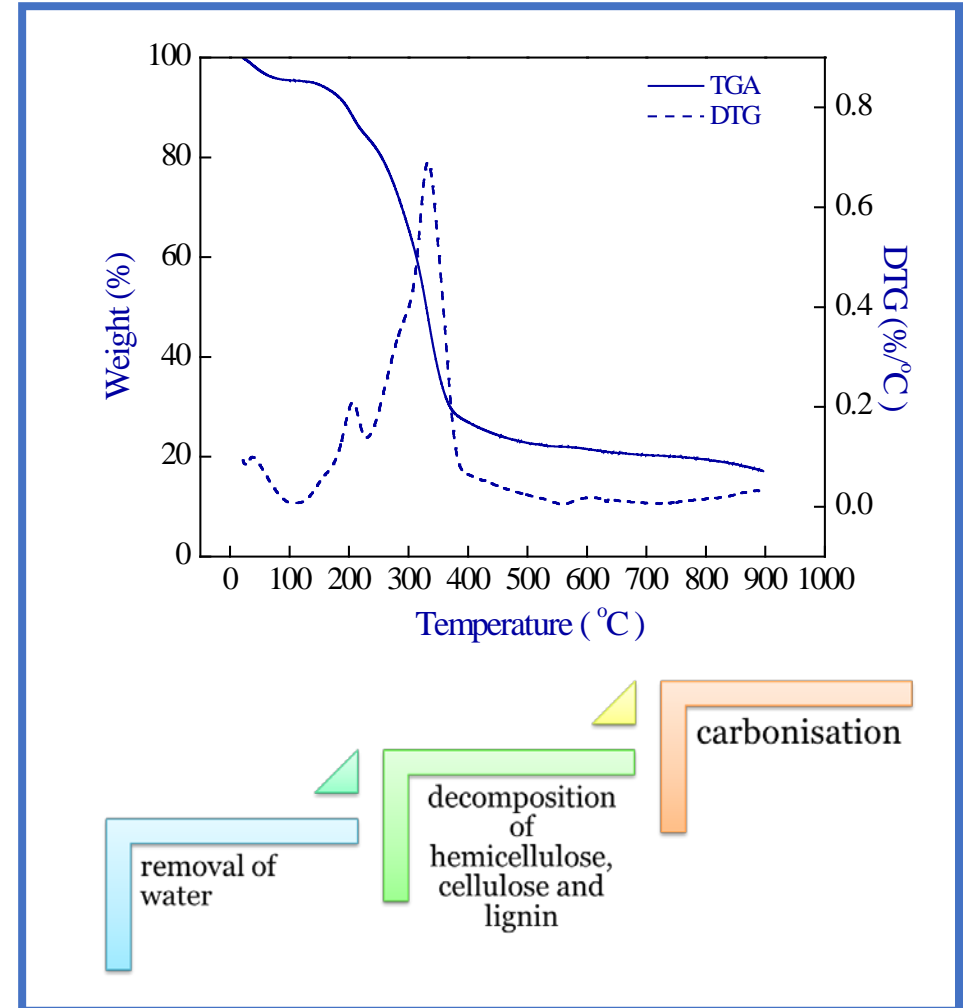
# IMPACT OF BIOCHARS ADDITION TO AGRICULTURAL SOIL ON THE SORPTION OF ATRAZINE

Beijing Normal University

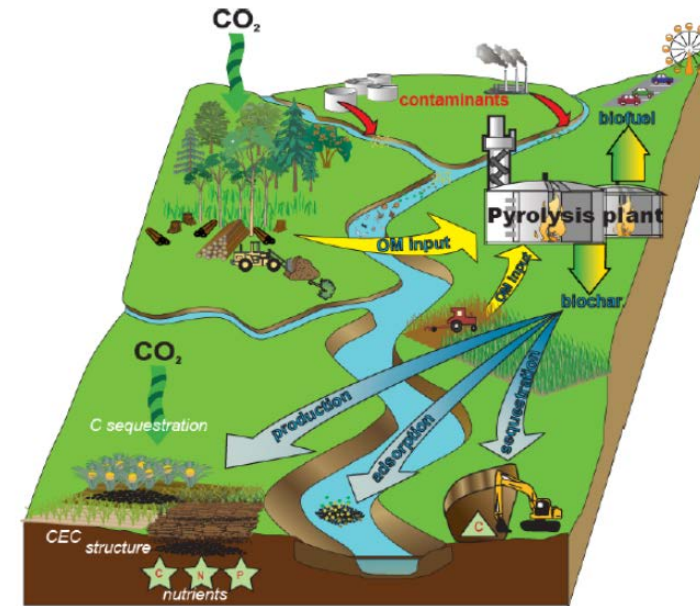


# Biochar

- The carbon rich residue produced when biomass is pyrolysed.
- Agricultural and forestry waste



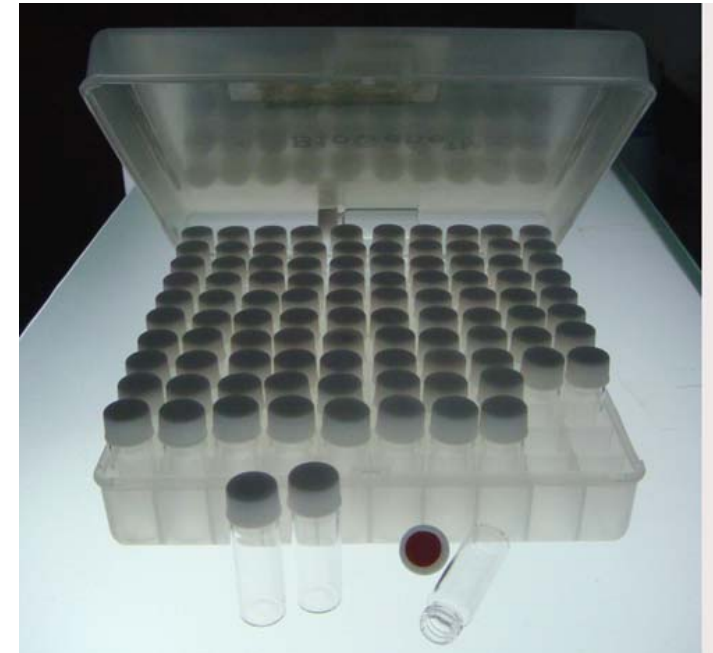
# Environmental applications of biochar



# Removal of atrazine from water with biochar



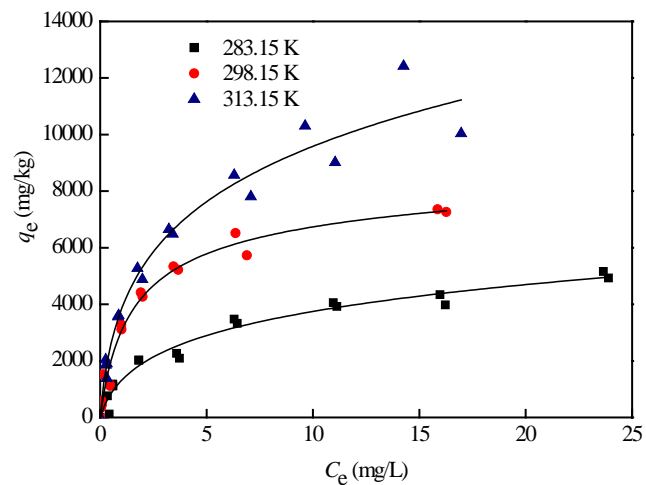
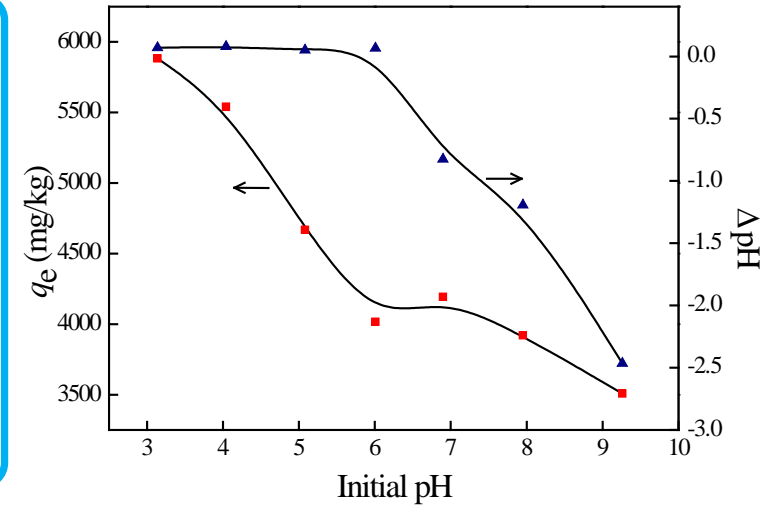
- Sorbent: biochar (CS450) 200 mg/L
  - Pollutant: atrazine 5mg/L
  - Method: batch equilibration method
- Studied the effect of
  - pH
    - initial pH ranged from 2.0 to 9.0
  - Temperature
    - T = 10, 25 and 40 degrees Celsius
    - initial pH = 7.0





# Results

- The variations of uptake amount ( $q_e$ ) in solutions of different pH suggests that the atrazine sorption capacity onto biochars was markedly affected by pH.
- More specifically, at pH < 6 for CS450, the  $q_e$  values of atrazine decreased dramatically with the increase in the pH, indicating that the sorption of biochar for atrazine was favoured by low pH.



- The uptake amount ( $q_e$ ) of atrazine from water with biochar (CS450) increased with the increase with temperature
- The higher temperature was a favourable factor in the atrazine sorption process.

# Biochar as soil amendment



## Experiment 1

Atrazine removal in aqueous solution

- (1mg/L and 20mg/L) with different amount of soil
- Control: without biochar addition.

## Experiment 2

Atrazine sorption experiments on soil amended by different biochars

- Soil + 0 to 5% of CS450 or SS450
- Different initial concentrations ( $C_0$ ) of Atrazine (1 to 30 mg/L)

# Results



## Pure soil and atrazine

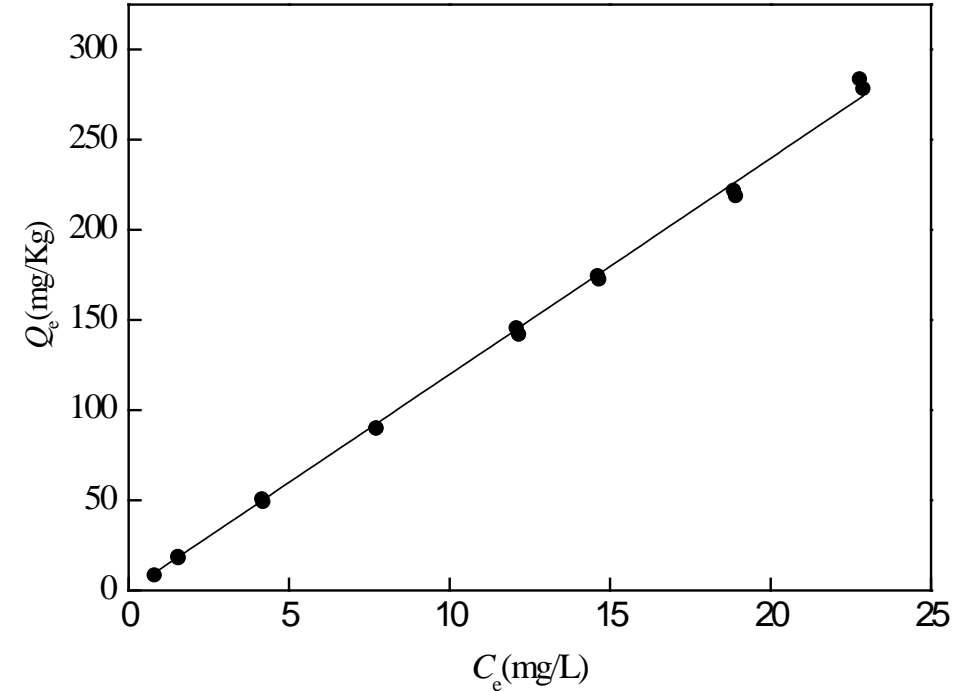
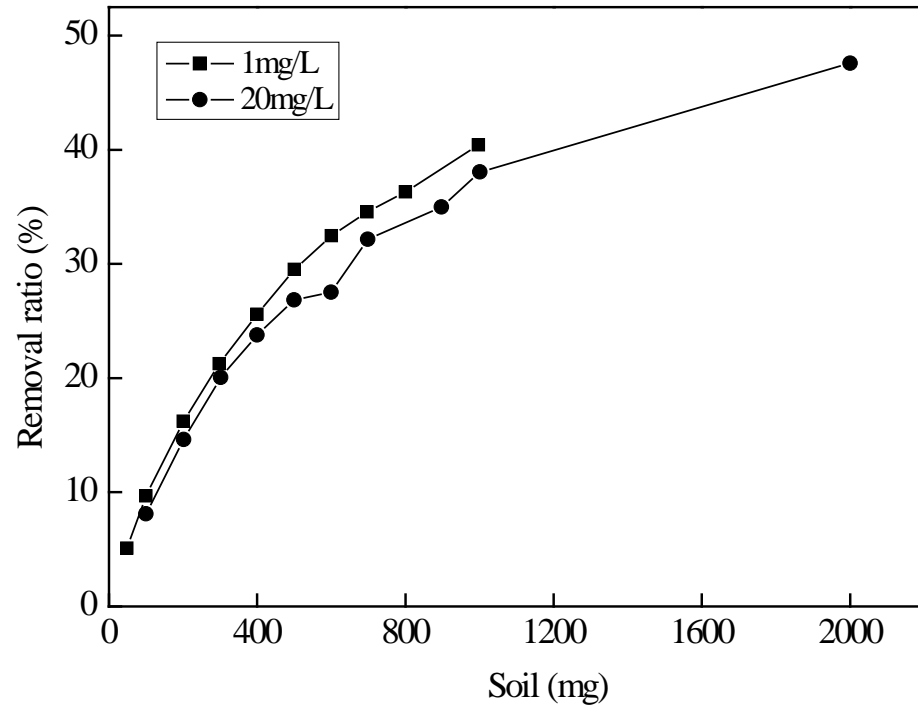


Fig. Relationship between soil amount and removal ratio of atrazine

Fig. Distribution isotherm of atrazine on soil

A removal ratio in solution increases with the amount of the soil added to the solution. Sorption of atrazine on soil fits good linear relationship.

# Results



## Isothermal sorption experiment of atrazine on different biochars amended soil

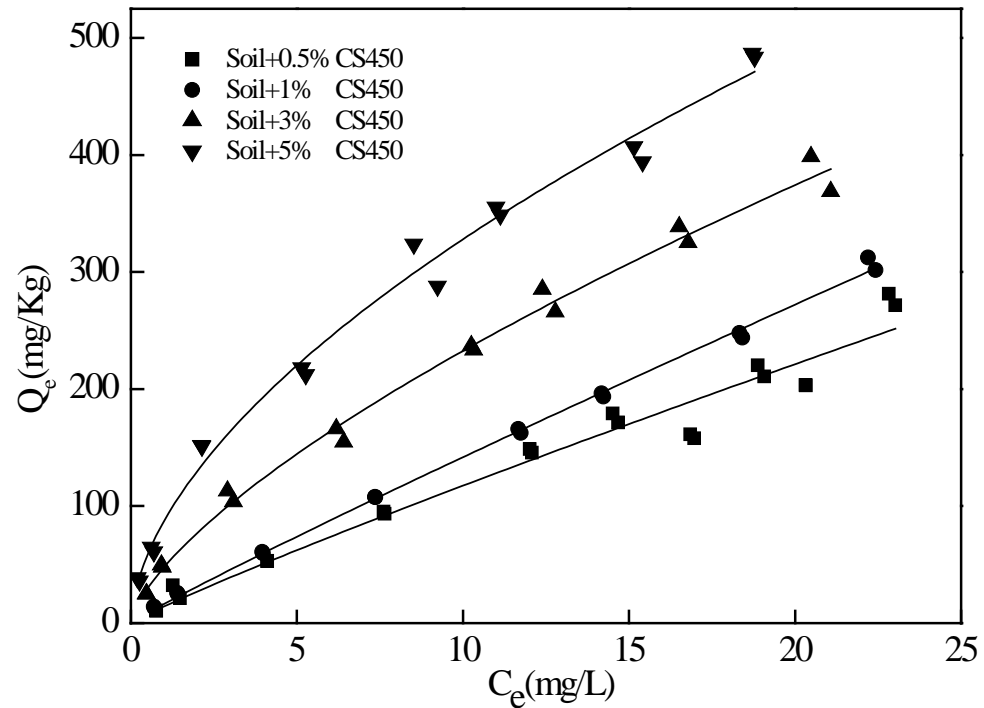


Fig. Freundlich Sorption isotherm of atrazine in soil by different amount of biochars amendment

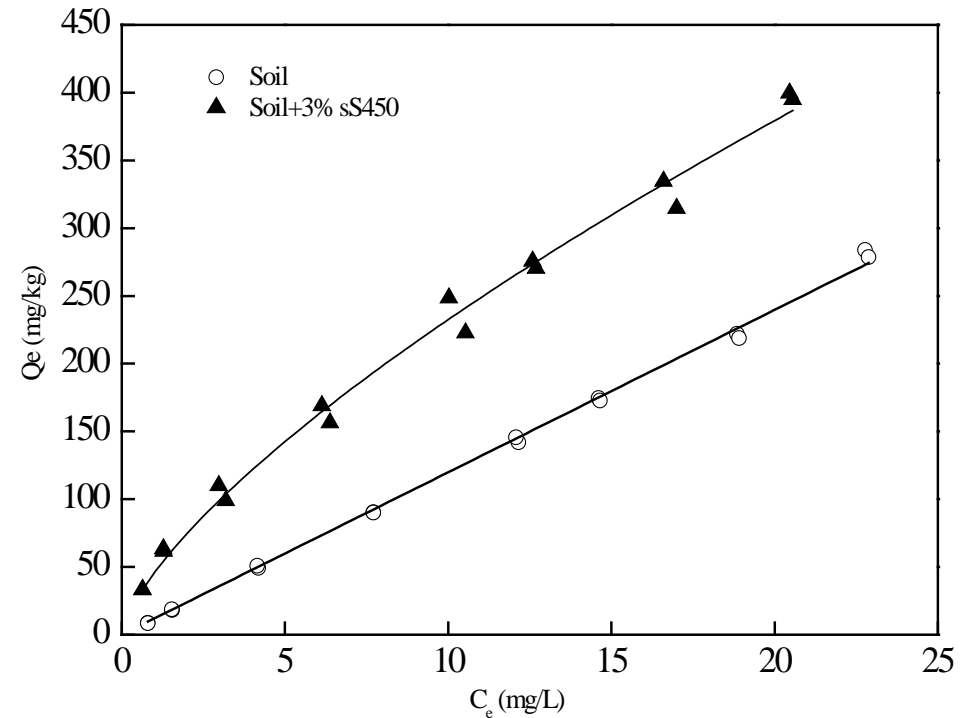


Fig. Freundlich Sorption isotherm of atrazine in soil and amended soil by SS450 biochars



# Conclusions

## *Transfer of PCDD/F from amendment to soil*

- Long term input of high amounts of PCDD/F increased both toxic and total concentrations in the soil
- Concentrations of furans in the soil increased more, although the input was higher for the dioxins

## *Biochar as amendment*

- The surface area of the biochar is important for the removal of Atrazine
- Biochar improved the removal of Atrazine, but was more pronounced at higher additions

# Acknowledgement

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