Nitrogen and Phosphorus Flows in the Food Chain and their Contributions to Non-Point Pollution in China

Ma Wenqi¹ Ma Lin²,³ Hou Yong¹ Gao Zhiling¹ Zhang Fusuo²

¹ Agricultural University of Hebei, China;
² China Agricultural University, China;
³ Wageningen University, the Netherlands.

(mawq@hebau.edu.cn).
Outline of presentation

- Background
- Objects
- Materials and methods
- Results and discussion
- Conclusions
Background

• Nitrogen (N) and Phosphorus (P) have 3 properties
  – They are essential nutrients for life (plants, animals, and humans) **Positive effect**
  – They are pollution factor (eutrophication of water bodies) **negative effect**
  – P is a disappearing resource (non-renewable resource)

N and P management is related to food security, resource use and environmental protection.
Background

N and P flow in food chain is the key process for nutrient management

• N and P effects is greatly depended on their flows and use efficiency in food chain
• Food demand is the main driving force for their flows
• It is very important to China

Ma et al., 2010
Fast change of society leads to increase of fertilizer demand and nutrient emission to environment

Increasing Population
Increasing urbanization
Improving life style
Increasing food demand

Driving force
Nutrient flow

Added: Animal food
Fruit
Lacked: microelements (Zn, Fe, Ca)

Increased:
Nutrient emission to environment

Added: waste

Decreasing nutrient cycling

Decreased Arable land
Increased: Yield
Area of economic crops

Energy/resource

Increased: Fertilizer/feed

Fast change of society leads to increase of fertilizer demand and nutrient emission to environment
The fertilizer production in China from 1961 to 2006

- **N**: 13 Yrs
- **P2O5**: 7 Yrs
- **K2O**: 4 Yrs
- **Total**: 2 Yrs


Fertilizer production (Mt):
- 1970: 10 Mt
- 2010: 50 Mt
- 1970: 30 Mt
- 2010: 40 Mt

Fertilizer production (Mt)
>30 Yrs
10 Mt
20 Mt
30 Mt
50 Mt
The environmental pollution caused by N, P etc has been very serious problem in China
**Background**

### Water quality of major rivers in China (2009)

<table>
<thead>
<tr>
<th>Main water system</th>
<th>Number of monitoring sections</th>
<th>Grade 1 (high-quality)</th>
<th>Grade 2 (good-quality)</th>
<th>Grade 3 (mediate-quality)</th>
<th>Grade 4 (poor-quality)</th>
<th>Grade 5 (bed-quality)</th>
<th>Worse than Grade 5 (very poor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changjiang</td>
<td>103</td>
<td>11.7</td>
<td>59.2</td>
<td>16.5</td>
<td></td>
<td></td>
<td>12.6</td>
</tr>
<tr>
<td>Huanghe</td>
<td>44</td>
<td>4.5</td>
<td>27.3</td>
<td>36.4</td>
<td></td>
<td></td>
<td>9.3</td>
</tr>
<tr>
<td>Zhujiang</td>
<td>33</td>
<td>18.2</td>
<td>48.5</td>
<td>18.2</td>
<td></td>
<td></td>
<td>15.1</td>
</tr>
<tr>
<td>Songhuajiang</td>
<td>42</td>
<td>0</td>
<td>11.9</td>
<td>28.6</td>
<td></td>
<td></td>
<td>59.5</td>
</tr>
<tr>
<td>Huaihe</td>
<td>86</td>
<td>0</td>
<td>14.0</td>
<td>23.3</td>
<td></td>
<td></td>
<td>62.7</td>
</tr>
<tr>
<td>Haihe</td>
<td>64</td>
<td>3.1</td>
<td>18.8</td>
<td>12.5</td>
<td></td>
<td></td>
<td>65.6</td>
</tr>
<tr>
<td>Liaohe</td>
<td>36</td>
<td>2.8</td>
<td>27.8</td>
<td>11.1</td>
<td></td>
<td></td>
<td>58.3</td>
</tr>
</tbody>
</table>

Source: China Statistical Yearbook on Environment of 2010

### Classification of surface water quality

<table>
<thead>
<tr>
<th></th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
<th>Grade 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN (mg/L)</td>
<td>0.20</td>
<td>0.05</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>TP (mg/L)</td>
<td>0.02</td>
<td>0.10</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>NH$_4^+$-N (mg/L)</td>
<td>0.15</td>
<td>0.50</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Background

Water quality of major freshwater lakes in China in 2009

64% of lakes were sorted to poor water quality

56% of lakes occurred eutrophication

Total number of lakes monitored: 25
Source: China Statistical Yearbook on Environment of 2010
## Background

### Comparison of water quality for major shallow lakes between 1980s and 2010s

<table>
<thead>
<tr>
<th>Lakes</th>
<th>Year</th>
<th>Nutrient content of water in lakes</th>
<th>Water quality</th>
<th>Degree of eutrophication</th>
<th>Main source of contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TN(mg/L)</td>
<td>TP(mg/L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taihu lake</td>
<td>1980s</td>
<td>1.11</td>
<td>0.052</td>
<td>Grand 3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2000s</td>
<td>2.57</td>
<td>0.078</td>
<td>Grand 6</td>
<td>Middle Eutropher</td>
</tr>
<tr>
<td>Dianchi lake</td>
<td>1980s</td>
<td>1.18</td>
<td>0.097</td>
<td>Grand 4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2000s</td>
<td>7.86</td>
<td>0.74</td>
<td>Grand 6</td>
<td>Middle Eutropher</td>
</tr>
<tr>
<td>Chaohu lake</td>
<td>1980s</td>
<td>1.43</td>
<td>0.088</td>
<td>Grand 4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2000s</td>
<td>2.23</td>
<td>0.190</td>
<td>Grand 6</td>
<td>Middle Eutropher</td>
</tr>
</tbody>
</table>

Source: Ministry of Environmental protection of China (2001-2006); National Statistical Bureau of China (2008 and 2009); Zhang W.L., et al 2004;
There is big change for N flow in food Chain of China

Unit: $10^4$ t

- 1952
- 2000

Ma et al., 2008
N and P flows in food chain of China in 2005

The NUFER model
(NUtrient flows in Food chains, Environment and Resources use).

Ma et al., JEQ, 2010
Objects of this study

1) To describe the status of N and P flows in food chain of China in different decades from 1980 to 2009
2) To evaluate resource and environmental cost of food consumption in China based on the N and P flows analysis
3) To analyze the contribution of N and P flows in food chain to environment pollutions.
Materials and Methods

The NUFER model

(NUtrient flows in Food chains, Environment and Resources use).

Compartments of NUFER:
- Crop production
- Animal production
- Households
- Food processing system

Definition of nutrient flows:
- Internal nutrient flow (between different sections)
- Outer nutrient flow (inputs/outputs of the whole food chain)

Ma et al., 2010
## Items in the NUFER model

<table>
<thead>
<tr>
<th>Compartment</th>
<th>Input/Output</th>
<th>Input</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop production</td>
<td>Input</td>
<td>Fertilizer</td>
<td>Animal manure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Human wastes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Residues to field</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Irrigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Deposition</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Biological nitrogen fixation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Seed</td>
</tr>
<tr>
<td></td>
<td>Output</td>
<td></td>
<td>Byproducts of food</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Crop products, residues, and grass</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\text{NH}_3$ emission</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\text{N}_2\text{O}$ emission</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Denitrification, runoff, leaching, erosion, and accumulation</td>
</tr>
<tr>
<td>Animal production</td>
<td>Input</td>
<td>Crop products, straw, and grass</td>
<td>Byproducts of plant food processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Byproducts of animal food processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kitchen residue</td>
</tr>
<tr>
<td></td>
<td>Output</td>
<td></td>
<td>Animal products and residues</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Manure to natural grassland, crop land, discharge, and $\text{NH}_3$, $\text{N}_2\text{O}$ emission, denitrification</td>
</tr>
<tr>
<td>Food processing</td>
<td>Input</td>
<td>Crop products</td>
<td>Animal products</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Food import</td>
</tr>
<tr>
<td></td>
<td>Output</td>
<td></td>
<td>Food, residues discharge, to nonfood sector, to animal feed, and return to field</td>
</tr>
<tr>
<td>Household</td>
<td>Input</td>
<td>Plant and animal food</td>
<td>Retained in body mass, excreta applied to crop land, food residue, emission to atmosphere, and discharge</td>
</tr>
</tbody>
</table>

Source from Ma et al., 2010
The Nitrogen flow in food chain of China

Input | production | consumption | Waste treatment
--- | --- | --- | ---

**Atmosphere**

- **Crop production**
  - Natural grass roughages (K)
  - Import Export (Aa, Ab, Ba, Ac)
  - Water body (Ca, Cb, Nb, Na)

- **Animal production**
  - Animal feed industry
  - Waste (solid and water) treatment

- **Food industry**
  - Household consumption

- **Waste treatment**
  - Discard and unused

**Natural fishery**

未发表资料
Materials and Methods

Data source

• Statistical data (from 1980 to 2009)
• Literature data
• Survey data
Results: Nitrogen flow in the food chain of China

- **1980:**
  - Crop Production: 17.3 Mt
  - Animal Production: 7.4 Mt
  - House-Hold: 2.8 Mt

- **1990:**
  - Crop Production: 28.9 Mt
  - Animal Production: 11.0 Mt
  - House-Hold: 3.5 Mt
  - Increase: +3.6 Mt

- **2000:**
  - Crop Production: 40.5 Mt
  - Animal Production: 18.1 Mt
  - House-Hold: 4.1 Mt
  - Increase: +8.1 Mt

- **2009:**
  - Crop Production: 46.7 Mt
  - Animal Production: 23.6 Mt
  - House-Hold: 4.7 Mt
  - Increase: +5.5 Mt

Unit: Million tonne (Mt)
Results: Nitrogen flow in the food chain of China

The change of N flux (Mt)

The increase of N flux (%)

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop Production</th>
<th>Animal Production</th>
<th>Households Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>20</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>1980</td>
<td>40</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>1990</td>
<td>60</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>2000</td>
<td>80</td>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>2010</td>
<td>100</td>
<td>50</td>
<td>20</td>
</tr>
</tbody>
</table>
Results: Phosphorus flow in the food chain of China

Unit: Million tonne (Mt)
Results: Phosphorus flow in the food chain of China

The change of P flux (Mt)

The increase of P flux (%)
Results: Resource and environment costs

Unit: kg

1980 N flow

- Chemical fertilizer: 3.3 kg
- Crop production: 2.0 kg
  - Grain: 2.0 kg
  - Residues: 1.2 kg
  - Feed: 2.6 kg

- Animal production: 1.0 kg
  - Animal product: 0.2 kg
  - Food consumed: 0.8 kg

- Recycling: 0.3 kg
- Others: 2.8 kg

2009 N flow

- Chemical fertilizer: 6.1 kg
- Crop production: 2.7 kg
  - Grain: 2.7 kg
  - Residues: 1.3 kg
  - Feed: 5.0 kg

- Animal production: 1.0 kg
  - Animal product: 0.5 kg
  - Food consumed: 0.3 kg

- Recycling: 0.4 kg
- Others: 3.8 kg

3.1 N lost to atmosphere in 1980

3.4 N lost to water bodies 2009

5.4 N lost to atmosphere 2009

1.2 N lost to water bodies in 1980

- N lost to atmosphere in 1980: 3.1 kg
- N lost to water bodies in 1980: 1.2 kg
- N lost to atmosphere 2009: 5.4 kg
- N lost to water bodies 2009: 3.4 kg
Results: Resource and environment costs

The change of N cost

The increase of N cost (%)
Resource and environment costs

1980 P flow
- Chemical fertilizer: 3.3
- Crop production: 3.6
  - Grain: 3.6
  - Residues: 1.2
    - Others: 0.6
    - Recycling: 0.3
  - Feed: 3.0
    - Others: 0.4
    - Recycling: 0.1
- Animal production: 1.9
  - Plant product: 2.8
    - Others: 0.9
  - Animal product: 0.2
- Food consumed: 1.0
- Household: 0.9
- Recycling: 0.4
- Water: 0.7
- Others: 0.1

P lost to water bodies in 1980: 0.9

2009 P flow
- Chemical fertilizer: 9.8
- Crop production: 5.0
  - Grain: 5.0
  - Residues: 1.5
    - Others: 0.6
    - Recycling: 0.3
  - Feed: 7.2
    - Others: 0.3
    - Recycling: 4.5
  - Animal production: 1.1
  - Animal product: 0.8
    - Food consumed: 0.2
- Household: 1.6
- Recycling: 0.4
- Water: 1.1
- Others: 0.2

P lost to water bodies 2009: 4.6
Results: Resource and environment costs

The change of P cost

The increase of P cost (%)

Fertilizer input
Feed input
Loss to water
Results: Nitrogen and phosphorus losses to environment

Total N losses to environment in 2009 is nearly 4 times that in 1980.
The ratio of N losses to water in total N losses is increasing.
**Results:** Nitrogen and phosphorus losses to environment

![Phosphorus losses graph]

- **Amount of P loss (Tg)**
- **Year**
- **1980**
- **1990**
- **2000**
- **2009**

- **P loss to..**
  - 34%
  - 51%
  - 15%
  - 100%
**Results:** Nitrogen and phosphorus losses to environment

![Nitrogen losses in crop systems](image)
Results: Nitrogen and phosphorus losses to environment

Phosphorus losses in crop systems

P loss (kt)
**Results:** Nitrogen and phosphorus losses to environment

Contribution of different systems to N losses

To atmosphere

<table>
<thead>
<tr>
<th>Year</th>
<th>Food Consumption</th>
<th>Animal Production</th>
<th>Crop Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To water bodies

<table>
<thead>
<tr>
<th>Year</th>
<th>Food Consumption</th>
<th>Animal Production</th>
<th>Crop Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results: Nitrogen and phosphorus losses to environment

Contribution of different production systems to P losses

To water bodies

- 1980: 12.4%
- 1990: 36.3%
- 2000: 68.2%
- 2009: 72.5%

Year:
- 1980
- 1990
- 2000
- 2009

Percentage (%):
- Food consumption
- Animal production
- Crop production
Discussion - uncertainty for the result of N and P loss to Environment

Comparison with National Survey for N and P discharged to water bodies

<table>
<thead>
<tr>
<th>Compartment</th>
<th>Element</th>
<th>National survey(^1) (2007)</th>
<th>This study (2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropping system</td>
<td>N</td>
<td>1.60</td>
<td>6.96</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.11</td>
<td>0.40</td>
</tr>
<tr>
<td>Animal system</td>
<td>N</td>
<td>1.02</td>
<td>6.77</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.16</td>
<td>1.99</td>
</tr>
<tr>
<td>Household</td>
<td>N</td>
<td>2.0 (Urban)</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>P</td>
<td>0.14 (Urban)</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Notes: 1 data derived from “The 1\(^{ST}\) national contamination survey of China (2007)”  Unit: Mt
**Calculation of N loss via surface runoff in NUFER Model**

**Equation:**
\[
N_{\text{surface runoff}} = \text{Corrected N surplus} \times LF_{\text{surface runoff, max}} \times f_{\text{lu}} \times \text{minimum of } (f_p, f_s, f_{rc})
\]

<table>
<thead>
<tr>
<th>Loss pathway</th>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LF_{\text{surface runoff, max}}</td>
<td>maximum surface runoff fraction for slope classes, % of total N input</td>
<td>6% for a slope of 0-7%&lt;br&gt;12% for a slope of 8-15%&lt;br&gt;21% for a slope of 16-25%&lt;br&gt;30% for a slope of &gt;25%</td>
</tr>
<tr>
<td></td>
<td>f_{lu}</td>
<td>reduction factor for land use</td>
<td>0.25 for grassland&lt;br&gt;1.00 for other land use</td>
</tr>
<tr>
<td>Surface runoff</td>
<td>f_p</td>
<td>reduction factor for precipitation surplus</td>
<td>1 for precipitation &gt;300mm&lt;br&gt;0.75 for precipitation 200-300mm&lt;br&gt;0.5 for precipitation 50-199mm&lt;br&gt;0.25 for precipitation &lt;50mm</td>
</tr>
<tr>
<td></td>
<td>f_s</td>
<td>reduction factor for soil type</td>
<td>0.9 for clay soil&lt;br&gt;0.75 for loamy soil&lt;br&gt;0.25 for peat soil</td>
</tr>
<tr>
<td></td>
<td>f_{rc}</td>
<td>reduction factor for depth of plough layer</td>
<td>1 for a soil depth of ( \leq 25) cm&lt;br&gt;0.8 for a soil depth of &gt;25cm</td>
</tr>
</tbody>
</table>

\(^1\)Corrected N surplus: total N input - N removal via harvested crop - NH\(_3\) and N\(_2\)O volatilization from fertilizers and crop residues

Note: this calculation is based on the modified MITERRA-EUROPE model
Calculation of potential N loss via leaching in NUFER Model

Equation:
N Leaching to outside of rooting zone (1 m) = Corrected N surplus * \(LF_{\text{soil type, max}}\) * \(f_{\text{lu}}\) * minimum of \((f_p, f_r, f_t, f_c)\)

<table>
<thead>
<tr>
<th>Loss pathway</th>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF (_{\text{soil type, max}})</td>
<td>maximum leaching fraction</td>
<td>100% for sandy soil 75% for loamy soil 50% for clay soil 25% for peat soil</td>
<td></td>
</tr>
<tr>
<td>(f_{\text{lu}})</td>
<td>reduction factor for land use</td>
<td>0.36 for grassland 1.00 for other land use</td>
<td></td>
</tr>
<tr>
<td>(f_c)</td>
<td>reduction factor for soil organic content</td>
<td>1 for total C &lt;1% 0.9 for total C 1-2% 0.75 for total C 2-5% 0.5 for total C&gt;5%</td>
<td></td>
</tr>
<tr>
<td>(f_p)</td>
<td>reduction factor for precipitation surplus</td>
<td>1 for precipitation &gt;300mm 0.75 for precipitation 200-300mm 0.5 for precipitation 50-199mm 0.25 for precipitation &lt;50mm</td>
<td></td>
</tr>
<tr>
<td>(F_t)</td>
<td>reduction factor for temperature</td>
<td>1 for a temperature &lt;5°C 0.75 for a temperature 5-15°C 0.5 for a temperature &gt;15°C</td>
<td></td>
</tr>
<tr>
<td>(f_r)</td>
<td>reduction factor for rooting depth</td>
<td>1 for a rooting depth of &lt; 1m 0.75 for a rooting depth of &gt;1m</td>
<td></td>
</tr>
</tbody>
</table>

\(^2\)Corrected N surplus: total N input - N removal via harvested crop - \(NH_3\) and \(N_2O\) volatilization - runoff – erosion loss

Note: this calculation is based on the modified MITERRA-EUROPE model.
Calculation of Erosion in NUFER model

\[ \text{N or P Erosion} = \text{N or P surplus} \times \text{Lferosion} \]

Lferosion: N or P Erosion factor

\[ \text{Lferosion} = \text{Lferosion max} \times \text{fp} \times \text{minimum of (flu, frc, fs).} \]

Reduction factors: fp, flu, frc, fs
Calculation of N and P losses via runoff and leaching in the national survey

Study area: Six geographical and ecological zones

Sub-classification: landform, climate, soil properties, crop types, cultivated patterns etc.

Method: Field experiment including two treatment: Ck (no fertilization) and conventional treatment

Indicators:
Ratio of fertilizer N or P loss via runoff or leaching

\[ \text{Ratio of fertilizer N or P loss via runoff or leaching} = \frac{\text{N/P losses in conventional treatment} - \text{N/P losses in CK}}{\text{the application rate of fertilizer N/P}} \]

Summary of ratio of fertilizer N and P losses via runoff and leaching in the 1st national contamination survey of China

<table>
<thead>
<tr>
<th>Study area</th>
<th>Runoff (%) N</th>
<th>Runoff (%) P</th>
<th>Leaching (%) N</th>
<th>Leaching (%) P</th>
</tr>
</thead>
<tbody>
<tr>
<td>The south (mountain area)</td>
<td>0.87</td>
<td>0.50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>The south (plain area)</td>
<td>1.13</td>
<td>0.48</td>
<td>1.98</td>
<td>0.33</td>
</tr>
<tr>
<td>The north China plain</td>
<td>0.86</td>
<td>0.36</td>
<td>1.48</td>
<td>0.01</td>
</tr>
<tr>
<td>The north (highland)</td>
<td>0.29</td>
<td>0.22</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>The north-west</td>
<td>0.38</td>
<td>0.22</td>
<td>0.76</td>
<td>0.03</td>
</tr>
<tr>
<td>The north- east</td>
<td>0.34</td>
<td>0.13</td>
<td>0.50</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Nitrogen Loss from Cropland

>2.0Mt Fertilizer N

- Crop recovery: 35%
- NH$_3$ volatilization: 11%
- Nitrification-Denitrification: 34%
- Runoff: 5%
- Leaching: 2%
- Unaccounted for: 13%

N$_2$O-N 1.1%

Zhu Z L & David Norse, 2000
Calculations of N and P losses from animal production in NUFER

Factors from literatures: \(\text{NH}_3\), \(\text{N}_2\text{O}\), \(\text{N}_2\)

Percentage of animal manure to soil from survey data

N and P discharge to surface waters
Calculation of N and P losses to water bodies in animal production in the national survey

**Study area:** Six geographical and ecological zones

**Sub-classification:**
- livestock types (Pig, meat cow, milk cow, meat chicken and egg chicken.
- Size of farm: small-sized farm, medium-sized intensive plant and large-sized intensive plant.
- breeding stage: 2-3 growth stages of each animal were considered
- manure treatment in housing: cleaning floor without water flushing (Ganqing fen); cleaning floor with water flushing (Shuichong fen);

**Indicator:** Amount (g/head/day) of TN or TP discharged into water from livestock production

**Example:** Amount of TN discharged into water (g N/head/day) from pig breeding in the north China

<table>
<thead>
<tr>
<th>Study area</th>
<th>Livestock type</th>
<th>Growth stage</th>
<th>The size of farm</th>
<th>Medium</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ganqing</td>
<td>Shuichong</td>
<td>Ganqing</td>
</tr>
<tr>
<td>The north China</td>
<td>Fattening pig</td>
<td>27kg</td>
<td>1.27</td>
<td>6.34</td>
<td>7.52</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70kg</td>
<td>3.47</td>
<td>9.33</td>
<td>13.65</td>
</tr>
<tr>
<td></td>
<td>Sow</td>
<td>210kg</td>
<td>3.61</td>
<td>10.11</td>
<td>19.03</td>
</tr>
</tbody>
</table>
Calculation of household N discharged to water in NUFER model

\[ Nw = \left( Ne \times Nfr \times \frac{(100 - Nfa)}{100}\right) \times \left(100 - Nr\right) \times \left[Rnt \times \left(100 - Rnd\right) + (100 - Rnt)\right] / 100 \] (1)

\[ Ne = P \times Nep \]
Calculation of N and P losses to water bodies in human activity

**Study area:** 31 Provinces in China (only urban area)

**Sub-systems:** household; accommodation and catering; hospital; motor vehicle; other service sector

**Example:** household sub-system

**Classification:** 31 provinces were grouped into 5 large-scale regions basing on economy level, human living custom and climate etc., after that within each of these regions, 5 sub-levels were classified according to human consumption level.

**Indicator:** Amount (g/capita/day) of TN or TP losses into water from human excrete

### Amount (g/capita/day) of TN and TP losses to water from human excrete in urban areas of China

<table>
<thead>
<tr>
<th></th>
<th>Sub-level 1</th>
<th></th>
<th>Sub-level 2</th>
<th></th>
<th>Sub-level 3</th>
<th></th>
<th>Sub-level 4</th>
<th></th>
<th>Sub-level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TN</td>
<td>TP</td>
<td>TN</td>
<td>TP</td>
<td>TN</td>
<td>TP</td>
<td>TN</td>
<td>TP</td>
<td>TN</td>
</tr>
<tr>
<td>Region 1</td>
<td>13.6</td>
<td>0.95</td>
<td>12.5</td>
<td>0.92</td>
<td>11.6</td>
<td>0.84</td>
<td>10.6</td>
<td>0.74</td>
<td>10.0</td>
</tr>
<tr>
<td>Region 2</td>
<td>13.9</td>
<td>1.16</td>
<td>12.9</td>
<td>1.05</td>
<td>11.6</td>
<td>0.95</td>
<td>11.0</td>
<td>0.84</td>
<td>10.3</td>
</tr>
<tr>
<td>Region 3</td>
<td>12.6</td>
<td>0.91</td>
<td>11.8</td>
<td>0.84</td>
<td>10.9</td>
<td>0.78</td>
<td>10.3</td>
<td>0.72</td>
<td>10.0</td>
</tr>
<tr>
<td>Region 4</td>
<td>13.7</td>
<td>1.3</td>
<td>12.8</td>
<td>1.14</td>
<td>11.9</td>
<td>1.02</td>
<td>11.1</td>
<td>0.91</td>
<td>10.4</td>
</tr>
<tr>
<td>Region 5</td>
<td>11.8</td>
<td>1.05</td>
<td>11.4</td>
<td>0.95</td>
<td>11.1</td>
<td>0.84</td>
<td>10.6</td>
<td>0.74</td>
<td>10.1</td>
</tr>
</tbody>
</table>

Note: region 1: Beijing, Tianjin, Hebei, Shandong, Shanxi, Inner Mongolia, Liaoqing, Jilin, Heilongjiang; region 2: Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, Guangxi, Hainan; region 3: Henan, Hubei, Hunan, Jiangxi, Anhui; region 4: Chongqing, Sichuan, Guizhou, Yunnan; region 4: Sanxi, Ningxia, Gansu, Qinghai, Xinjiang, Xizang.
Conclusions

• N and P flux in food chain of China has been increased significantly from 1980 to 2009
• For producing 1 kg N and P of food consumed from 1980 to 2009, the amounts of N and P fertilizers applied to farmlands and the losses to environment were increased by several times.
Conclusions

• There was a significant increase in the contribution of N and P losses to water bodies from animal production.
• Human food consumption especially increasing animal food plays an important role for N and P flows in whole food chain and their losses to environment.
Thanks for your attention!